TM 11-2004

WAR DEPARTMENT

TECHNICAL MANUAL

REPEATER SET TC-18 (TERMINAL)

12 AUGUST, 1943

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WAR DEPARTMENT
WASHINGTON, 8/12/43

This Technical Manual, published by the Western Electric Company on Order No. 32751 Phila.-43, is furnished for the information and guidance of all concerned.

X-61882, ISSUE 3

TECHNICAL MANUAL
NO. 11-2004

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REPEATER SET TC-18
(TERMINAL)

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DESTRUCTION NOTICE

WHY: To prevent the enemy from using or salvaging this equipment for his benefit.

WHEN: When ordered by your commander, or when you are in immediate danger of capture.

HOW:
1. Smash. Use sledges, axes, hand-axes, pick-axes, hammers, crowbars, heavy tools, etc.
2. Cut. Use axes, hand-axes, machetes, etc.
3. Burn. Use gasoline, kerosene, oil, flame-throwers, incendiary grenades, etc.
4. Explosives. Use firearms, grenades, TNT, etc.
5. Disposal. Bury in slit trenches, fox-holes, other holes. Throw in streams. Scatter.
6. USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT.

WHAT:
1. Smash. Open carrying case cover, open panels. Smash relays, meter, resistors, capacitors. Smash framework.
2. Cut. Transformer coil windings, relay windings, all wiring and cables.
3. Bend and/or Break. Frameworks and panels.
4. Burn. Carrying case, manuals in cover.
5. Bury or scatter. Any or all of the above pieces after breaking.

DESTROY EVERYTHING

SAFETY NOTICE

IF NECESSARY TO REMOVE THE REPEATER FROM THE CARRYING CASE, DISCONNECT POWER CORD FROM THE POWER SOURCE. AVOID TOUCHING TERMINALS WITH BARE HANDS WHILE TESTING. ALL TEST LEADS SHOULD BE INSULATED.

NOTICE

Use Test Set I-193-A for testing and adjusting the polar relays.

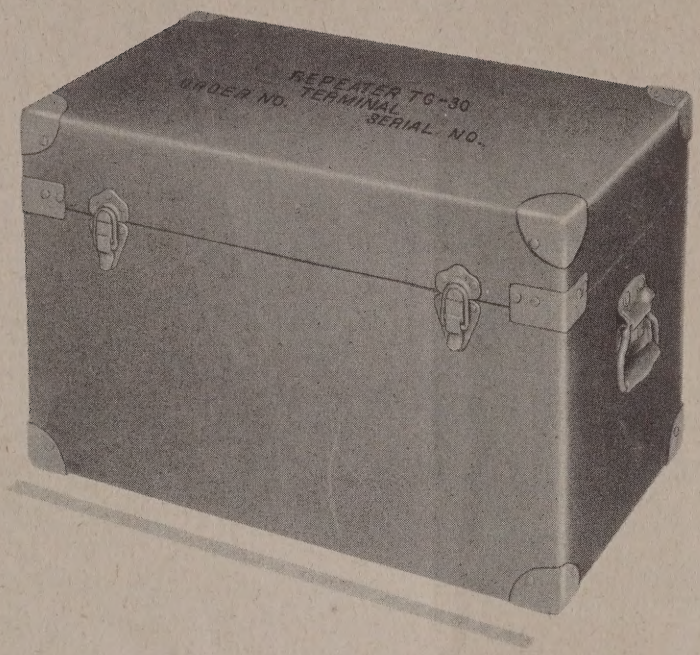


Figure 1 - Repeater TG-30 (Terminal), Ready for Transit

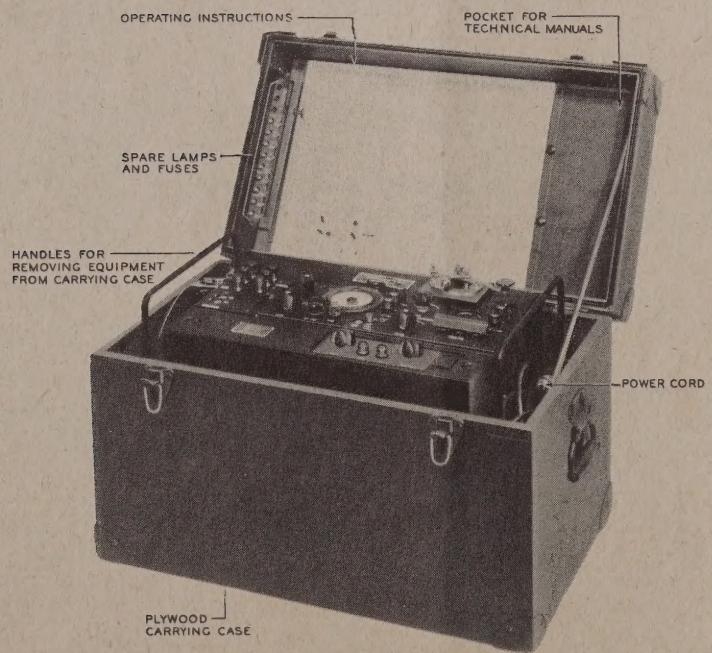


Figure 2 - Repeater TG-30 (Terminal), Carrying Case Open for Service

SECTION I
DESCRIPTION

1. PURPOSE.

a. General.—Repeater Set TC-18 (Terminal) consists of two Ground Rods GP-29 and one Repeater TG-30 (Terminal). The remainder of this manual is concerned with Repeater TG-30 (Terminal). Repeater TG-30 (Terminal) is a d-c telegraph terminal repeater for transmitting to and receiving from another telegraph Repeater TG-30 (Terminal) or its equivalent at distant terminal on a half-duplex basis, either with or without Repeater TG-31 (Intermediate), at an intermediate point. Two Repeaters TG-30 may be connected together to provide an intermediate repeater. This equipment may be used on 60-speed (368 operations per minute) or 66-speed (404 operations per minute) printer circuits. The repeater is designed for operation on field-wire line circuits (simplexed) or open-wire circuits (composited) with ground return. The repeater contains a built-in-rectifier power unit. A manual telegraph set integral with the repeater equipment is used when printer equipment is not available.

b. Line Operation.—The line side of the repeater is arranged to use either the type B polarential form of transmission or 2-path polar transmission.

c. Local Operation.—The local side of the repeater is arranged for operation with a printer or 30-milliampere or 60-milliampere neutral (open and close) local circuits or the manual telegraph set.

2. EQUIPMENT ARRANGEMENTS.

The repeater is portable and is housed in a durable wooden carrying case which completely encloses all equipment while in transit, as shown in figure 1. The major component circuits are a repeater circuit and a rectifier power circuit. The apparatus comprising these circuits is assembled on mounting plates and panels attached to a framework which is supported on shockproof mountings. The complete assembly may be easily removed from the carrying case and mounted on a 19-inch relay rack. Connecting terminals, jacks, switches, potentiometers, fuses (with spares), and a meter required for setting up and operating the repeater are conveniently assembled and clearly designated on the face of the equipment. The repeater with the carrying case open for service is shown in figure 2. The repeater equipment is furnished with a receptacle and jacks for connecting the printer (power and transmission cords), a jack for connecting the telephone receiver used with the manual telegraph operation, and a jack which supplies power for operating the relay test set. The repeater employs three polar relays of

the same type. One spare polar relay is located in the compartment housing the repeater polar relays. Storage space is located inside the cover of the carrying case for additional spare fuses, spare neon lamps (used in the manual telegraph set circuit), and the Technical Manuals. A summary of operating instructions is attached inside the cover. Line protectors and spares are located inside the repeater unit. The telephone receiver, with its associated cord and plug, is held in a clamp on the side of the unit when not in use. The equipment is built for use over a wide temperature range and for use under tropical conditions. A communication break feature is incorporated in the repeater design. Filters to suppress induction from power lines are not supplied.

3. POWER.

The repeater circuits require ungrounded 115 volts d-c. The primary power source for operating the equipment may be alternating current (commercial or gas-engine power unit) or direct current (gas-engine power unit). A selenium disc-type rectifier is used to convert a-c power to d-c power. Repeater TG-30 (Terminal) may be operated from either:

95 to 125 volts, 50 to 60 cycles a-c

190 to 250 volts, 50 to 60 cycles a-c

115 volts d-c (gas-engine Power Unit PE-77-( ) or equivalent)

A 10-foot flexible cord is attached to the repeater for connecting to these power supplies. Power switches are used to arrange the repeater for the source of power available. The rectifier power unit contains an autotransformer and a 2-winding transformer. The autotransformer has a 115-volt tap for furnishing power to the printer motor when the power source is 230 volts a-c and it is supplied with fine taps for regulating the voltage applied to the primary of the 2-winding transformer. The 2-winding transformer has coarse taps for regulating the voltage applied to the rectifier selenium discs. The required output of 115 volts d-c is obtained by operating switches associated with the fine and coarse taps. A master power switch is supplied to arrange the repeater for operation on alternating or direct current. A supplementary switch is supplied to arrange the repeater for operation on 115 volts a-c or 230 volts a-c. Power is removed from the repeater by disconnecting the power cord. The full load output rating of the rectifier is 400 milliamperes at 115 volts. The output voltage is sufficiently constant for operation of the repeater under normal load variations. It is not equipped with automatic regulation. When the equipment is operated from an a-c supply, approximately 80 watts of power will be required for the rectifier and an additional 120 watts when a printer is used making a total of 200 watts.

When a d-c supply is used, the repeater circuit will require approximately 50 watts and the printer 90 watts, making a total of 140 watts. When operation is from 115 volts d-c, the supply (Power Unit PE-77-( ) or equivalent) must be nongrounded and the voltage regulated externally because no d-c power adjustment is furnished with the repeater. The transmitting branch of the repeater contains a potentiometer for reducing the 115 volts d-c to 75 volts d-c for transmission from the contacts of the sending relays as required for certain forms of line operation.

4. LINE TRANSMISSION FEATURES.

a. General.—The line side of Repeater TG-30 (Terminal) is designed to permit either type B polarential or 2-path polar operation. Telegraph repeaters, such as Repeater TG-30, using the type B polarential or 2-path polar principle of transmission do not require service adjustments to compensate for the variations in the electrical characteristics of the line due to changes in leakage resistance and grounded capacity as a result of changing weather conditions. Hereafter, type B polarential operation will be referred to as polarential operation. Two-path polar circuits require two independent telegraph channels between two repeater points, whereas polarential circuits require only one telegraph channel between two repeater points.

b. Polarential Operation.—Fundamentally, a circuit operating on a polarential basis uses polar transmission in one direction and differential transmission in the other direction. These two terms have been combined to form the word polarential. Figure 3 is a theoretical schematic of polarential operation. In a polar transmission system, the marking and spacing line currents are of the same magnitude and flow in opposite directions, and hence, the receiving relay operates on reversals of line current and requires no local bias circuit. In a differential transmission system, the marking and spacing line currents are different in magnitude, and this difference as applied to the polarential method of operation requires a spacing current in one direction of transmission about 2-1/2 times the marking current. The spacing current is in the same direction as the marking current and a repeater receiving marking and spacing currents flowing in the same direction requires a local biasing circuit on the receiving relay. By fixing this local biasing circuit in a marking direction at half the sum of the received marking and spacing line currents, and poling the line winding of the receiving relay spacing, the net effect on the armature of the receiving relay is equivalent to polar transmission. To get this equivalent of polar transmission in both directions on one telegraph channel, the opposite ends of a polarential circuit are made dissimilar as regards the connections of the sending and receiving relay circuits and the operating voltages applied

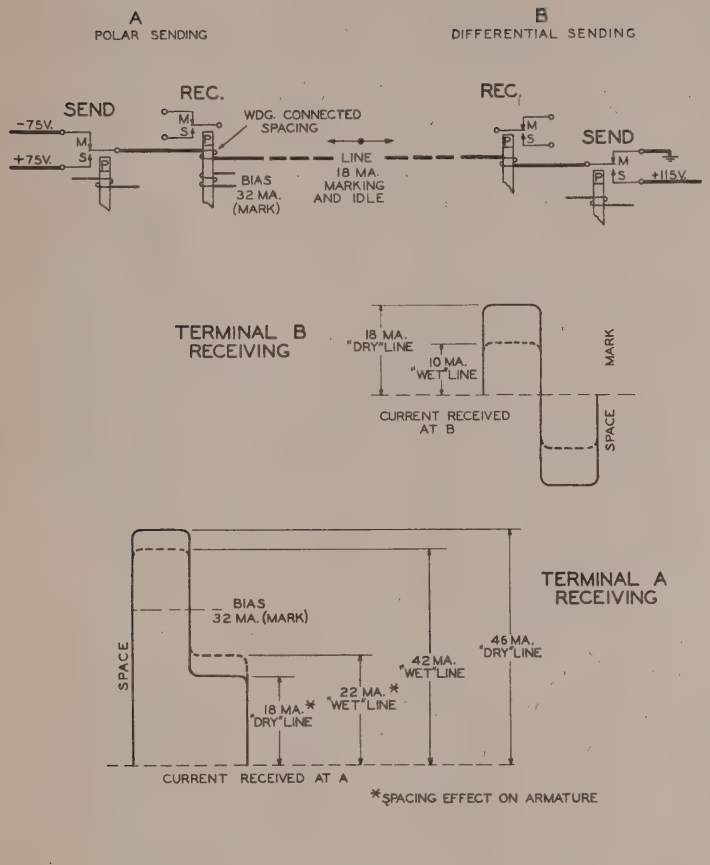


Figure 3 - Theoretical Schematic of Polarential Operation

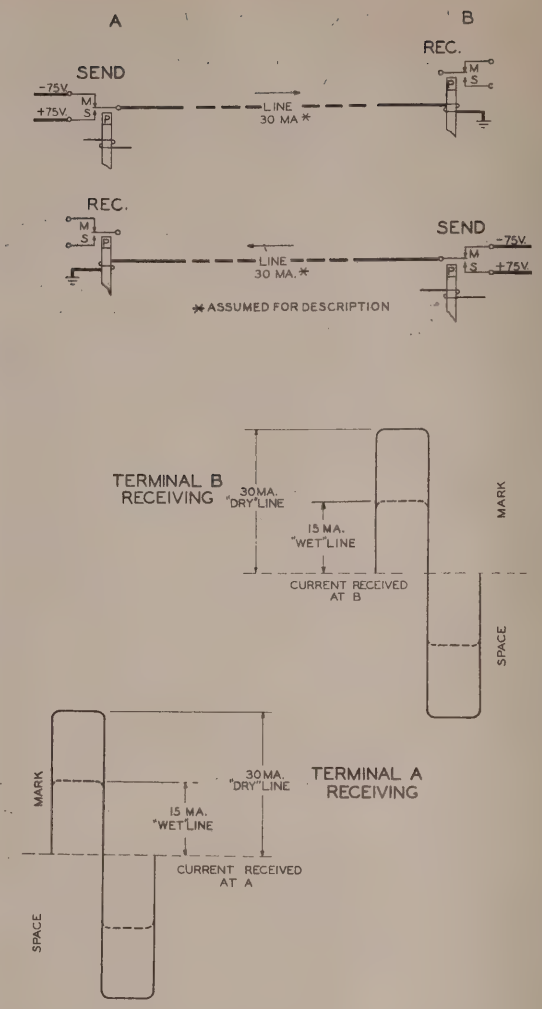


Figure 4 - Theoretical Schematic of 2-path Polar Operation

to the line. One end of the circuit applies negative and positive polarity of the same value while sending and this is known as the polar sending end of the circuit. The other end of the circuit applies ground for marking and positive polarity for spacing and is known as the differential sending end of the circuit. The positive polarity at the differential sending end is approximately twice the value of the negative or positive polarity applied at the polar sending end. The theoretical schematic, figure 3, represents a system in which the repeaters are equivalent to Repeater TG-30 (Terminal), except that the current assumed for the bias winding of the receiving relay at the polar sending end is the proper current for a relay with an equal number of turns for the line winding and the bias winding. The windings of the polar relay used in Repeater TG-30 (Terminal) do not have an equal number of turns.

c. Two-path Polar Operation.—Two-path polar transmission utilizes one telegraph channel for signals transmitted; for example, from terminal A to terminal B and another entirely independent telegraph channel for signals transmitted from terminal B to terminal A. A theoretical schematic of 2-path polar operation is shown in figure 4. The circuit of the sending relay contacts and receiving relay windings at both ends of the line circuit are identical. A specific value of line current is not required since the receiving relay operates on reversals, but it should not be less than 10 milliamperes and not more than 30 milliamperes.

5. SERVICE APPLICATIONS.

Repeater TG-30 (Terminal) is designed to give service optionally in combination with itself and other equipment as follows:

a. Line Operation.

(1) Repeater TG-30 (Terminal), polarential or 2-path polar.

(2) Repeater TG-31 (Intermediate), polarential.

(3) Telegraph Terminal CF-2-( ) (Carrier), polarential or 2-path polar.

(4) X-61822 VF Carrier Telegraph System, polarential or 2-path polar.

(5) X-61824 D-C Telegraph Repeater (Terminal), polarential or 2-path polar.

(6) 2-path polar terminations.

b. Local Operation.

(1) Printer TG-7-( ).

(2) Switchboard BD-100.

(3) Line Unit BE-77 or BE-77-A.

(4) Printer Station having Printer equipped with line relay.

(5) Telegraph Terminal CF-2-( ) (Carrier).

(6) Repeater TG-29-( ) (Electronic, Regenerative).

(7) Repeater TG-30 (Terminal).

(8) Manual Telegraph Set (Part of Repeater TG-30).

6. METHODS OF OBTAINING OPTIONS FOR LINE AND LOCAL OPERATION.

The line and local circuit features required for different forms of service are obtained by turning a LINE switch and a LOCAL switch to specific positions and by connecting wires to specific LINE and LOCAL binding posts. A combination of the LINE switch position and the LINE binding post connec-

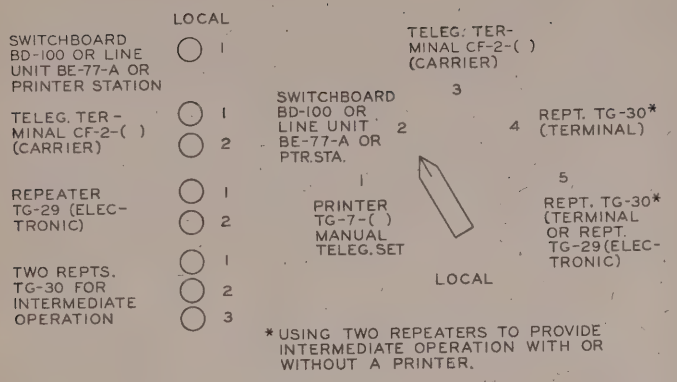


Figure 5 - Functions of Local Binding Posts and Local Switch

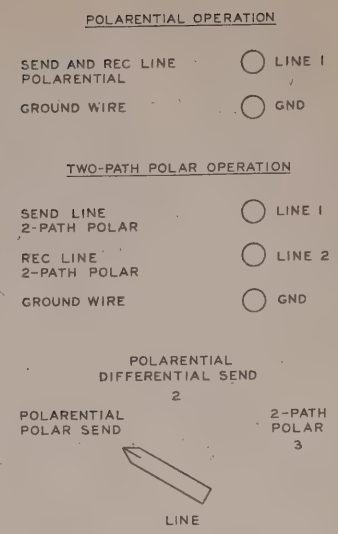


Figure 6 - Functions of Line Binding Posts and Line Switch

tions provides the required line circuit arrangements and a combination of the LOCAL switch and LOCAL binding post connections provides the required local circuit arrangement. (Refer to figs. 5 and 6.) The line and local switches are multicontact switches. The line switch is a 3-position switch, and the local switch is a 5-position switch. No switching relays are used. Two LINE binding posts, one GND binding post, and three LOCAL binding posts are needed.

7. MANUAL TELEGRAPH OPERATION.

A manual telegraph set is built in to permit a means of communication when printer equipment is not available or cannot be operated. The component parts of this set consist of a small neon lamp connected in an oscillating circuit, a telegraph key, and a 1000-ohm telephone receiver (headset). The headset is supplied with a cord and plug for connecting to a HEADSET jack in the repeater. The neon lamp and the telegraph key are normally connected to the repeater and are available for service when the headset is connected. The frequency of the oscillator (neon lamp) is adjustable by means of a potentiometer with a knob conveniently located on the operating panel. The frequency of the oscillator, that is, the tone heard in the receiver, may be regulated to suit using personnel. A tone in the order of 1000 cycles should generally be satisfactory. The manual telegraph set is inoperative when a printer is connected.

8. LINE PROTECTION.

Carbon block line protectors prevent damage to the equipment in case of line voltage surges. One pair of protector blocks is connected to each line binding post of the repeater. Two pairs of protector blocks are supplied as spares. These blocks have an air gap of about .005 inch.

9. NOISE INFLUENCE ON TELEPHONE CIRCUITS.

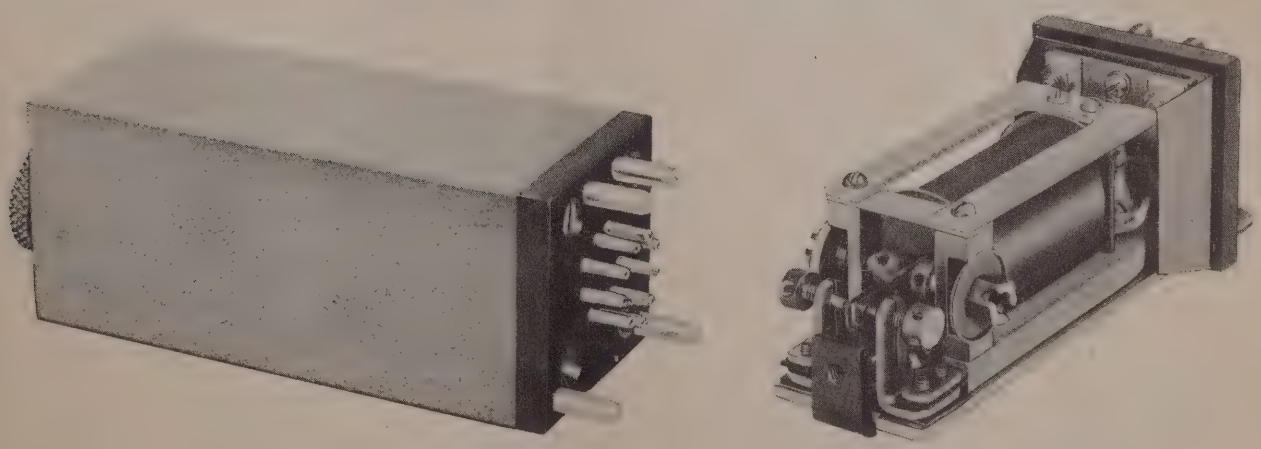
Repeater TG-30 (Terminal) is furnished with a retardation coil in series in the line circuit to serve as a noise killer to prevent undesirable noise on simplexed telephone circuits. In addition, a noise filter is needed on composited circuits to maintain the same noise level standard as on simplexed circuits. This noise filter should be provided with the composite equipment.

10. RADIO INDUCTION SUPPRESSION.

The wiring to the line and local binding posts, and to the send and receive printer jacks is carried through lead filters and the power cord and wiring to the printer power receptacle is supplied with power-lead filters to reduce interference to nearby radio receiving equipment. These filters contain low-resistance air-core coils and small by-pass capacitors. The filters are effective in a range from about 200 kilocycles to 18,000 kilocycles.

11. TELEGRAPH POLAR RELAYS.—(Fig. 7)

The repeater uses three polar relays of the same type (coded D-164816). It is a 3-winding relay and is arranged for mounting in a vacuum tube socket which serves as a connecting block. It weighs one pound and one ounce. One



Cover in Place Cover Removed

Figure 7 - Polar Relay D-164816

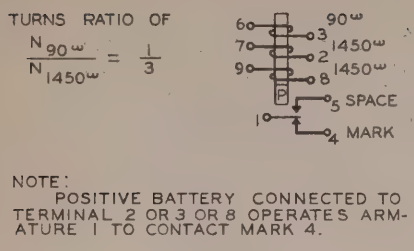


Figure 8 - Schematic Circuit of Polar Relay D-164816

winding is a 90-ohm winding and the other two are 1450-ohm windings. Figure 8 is a schematic circuit of the relay. The relay D-164816 is tested and adjusted by use of Test Set I-193-A.

12. LINE CONDUCTORS AND OPERATING RANGES.

a. Line Conductors.—This repeater may be operated on all types of line conductors, the more common of which are as follows:

Field Wire W-110-B, Simplexed.
Field Wire W-143, Simplexed.
104-mil Copper, Open-wire Line, Composited.
80-mil, 40 Per Cent Copper-steel, Open-wire Line, Composited.
104-mil, 40 Per Cent Copper-steel, Open-wire Line, Composited.

Open-wire circuits may be operated simplexed as well as composited. The following operating ranges in Table I are provided as a guide in laying out circuits. Do not use them as the absolute operating ranges under all conditions. The presence of earth potential, power line induction, or ground resistance reduces operating ranges. The distances specified for operation on field wire circuits are based on adverse weather conditions with wire laid on the ground and with a maximum capacity-to-ground in the order of 8/10 microfarad per mile and a maximum leakage of 1/4 megohm per mile. The distances estimated for open-wire lines are based on a maximum leakage to ground of 1/4 megohm per mile and a maximum leakage between the wires of a pair of 3-1/2 megohms per mile. In case the leakage resistance between wires of a pair is substantially less than this value, it may not be possible to use the pair for more than one telegraph circuit. Capacity-to-ground on open-wire lines is not effective towards reducing operating ranges and it is very low.

b. Operating Ranges (See Table I on opposite page).

13. DIMENSIONS AND WEIGHTS.

The over-all dimensions of the carrying case are:

Length - 25 inches.
Height - 16 inches.
Depth - 14-1/2 inches.

The total weight including all spare equipment is 130 pounds. The shipping space required is 3-1/2 cubic feet.

TABLE I

GUIDE FOR DETERMINING OPERATING RANGES

(Refer to Par. 5 for Nomenclature of Equipments)

368 Operations per Minute. See Note A.

Polarential or 2-path Polar Operation	W-110-B Simplexed	W-143 Simplexed	104 Mil Copper Composited	80 Mil 40% Copper-steel Composited	104 Mil 40% Copper-steel Composited
TG-30 to TG-30 Single-line section	50 miles	75 miles	200 miles	95 miles	135 miles
TG-30 to TG-30 with TG-31 Two-line sections	Two 40-mile sections. Total 80 miles	Two 40-mile sections. Total 80 miles	Two 200-mile sections. Total 400 miles	Two 50-mile sections. Total 100 miles	Two 100-mile sections. Total 200 miles
TG-30 to CF-2-( ) Single-line section	25 miles	40 miles	Note B	Note B	Note B

Note A - Circuits operating at 404 operations per minute should be reduced in length to retain the same quality of transmission as obtainable at 368 operations per minute; or if the above lengths are retained, the quality of transmission will be reduced at 404 operations per minute. Typical operating ranges without reduction of transmission below a bias tolerance of 15 on single-section lines between two Repeaters TG-30 with printers are:

Type of Wire	368 Operations per Minute	404 Operations per Minute*
W-110-B	50 miles	40 miles
W-143	75 miles	70 miles
104 mil Copper	200 miles	200 miles
80 mil 40% Copper-steel	95 miles	95 miles
104 mil 40% Copper-steel	135 miles	135 miles

*With orientation range scale 50 except for W-110-B wire.

Note B - Field wire lines are assumed for d-c extension facilities from carrier telegraph terminals.

Note C - A Repeater TG-30 may be employed on one end of a line section and an X-61824 D-C Telegraph Repeater (Terminal) on the other end. Repeater TG-30 may be employed on a polarential or 2-path polar basis to an X-61822 VF Carrier Telegraph Terminal.

Note D - At 368 o.p.m. not more than two line sections can be operated in tandem without employing a regenerative repeater. At 404 o.p.m. a regenerative repeater may be required at each intermediate point.

SECTION II
INSTALLATION AND OPERATION

14. OPERATING INSTRUCTIONS.

a. General.—A facsimile of the condensed operating instructions attached inside the cover of each repeater carrying case is shown in figure 37. Line up the repeater for service in the order shown in figure 37.

b. Local Connections.—In all local circuits, the currents are adjusted in the connected equipment and not in Repeater TG-30. In general, local operation means that the equipments involved are located within a few hundred feet of each other. However, operation to a printer with a line relay, Switchboard BD-100, or Line Unit BE-77 or BE-77-A, may be employed up to a maximum distance of 4 miles on field wire (simplex or multipled pair) with limitations in accordance with paragraphs 19 and 25.

c. Orientation Range Setting of Printer.—Set the orientation range pointer on the scale at 50 to 55. At 404 operations per minute the setting should be 50 for all types of wires except Wire W-110-B. Refer to paragraph 34d.

15. GROUNDING.

Since this equipment is for operation on ground-return circuits the resistance of the connection to earth is equal in importance to the resistance of the metallic-line conductor. Make every effort to obtain the best ground connection available in the area where service is to be established. It is preferable to run a ground lead a few miles (field wire multipled is satisfactory) to a water pipe system or well rather than to drive ground rods in soil not well covered with vegetation or in dry soil. Drive ground rods to their full length and, except when the earth is moist, drive two rods at least 25 feet apart. Ground rods driven into the earth surrounding the roots of trees generally result in a satisfactory low-resistance ground connection.

16. PREPARATION FOR USE, THROWING POWER SWITCHES, AND CONNECTING PRINTER.

a. General.—When service requires the use of a printer, locate the repeater to the right of the printer. Check the power supply available as to its reliability and determine if the supply is to be 115 volts a-c or 230 volts a-c or 115 volts d-c (gas-engine power unit).

CAUTION: Do not connect the power cord until switches have been correctly thrown for the power supply and the wires connected and the ADJ LINE CURRENT knob COARSE set at the maximum counterclockwise (to the left) position.

b. Grounding Repeater.—Connect ground wire to terminal GND for all forms of line and local operation.

c. Throwing Power Switches for A-C Power Supply.—If the power supply is alternating current, open the small door on the right-hand forward position of the equipment and throw the toggle switch to 115V or 230V as required. Throw the master AC - DC power switch on the repeater to the position designated 115V or 230V AC.

d. Throwing Power Switches for D-C Power Supply (Gas-engine Power Unit).—If the power supply is direct current, throw the master AC - DC power switch on the repeater unit to the position designated 115V DC.

e. Connecting Printer TG-7-( ).—Connect the printer cord with the red plug to the PRINTER jack marked R RED. This is the receiving magnet circuit. Connect the printer cord with the black plug to the PRINTER jack marked S BLK. This is the sending contacts circuit. Connect the printer power cord to the receptacle marked PRINTER POWER. This circuit supplies power to the printer motor.

f. Initial Setting for ADJ LINE CURRENT Switch COARSE.—Before connecting the power cord, turn the ADJ LINE CURRENT knob COARSE to the maximum counterclockwise (to the left) position if the LINE switch is to be turned to position 1 or 3. This introduces sufficient resistance in series in the line to prevent blowing fuses when the line facility resistance is very low.

17. TERMINAL-TO-TERMINAL WITH PRINTER TG-7-( ), (FIG. 9).

When service is on a polarential basis, arrange the repeater at terminal A as the polar-sending repeater (LINE switch in position 1), and the repeater at terminal B as the differential-sending repeater (LINE switch in position 2). Adjust the line current at the repeater arranged for polar sending (terminal A). If a 2-path polar line operation is employed, ad-

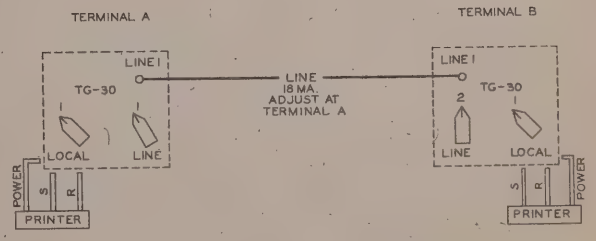


Figure 9 - Terminal-to-terminal with Printer

just the line current in the sending line at each terminal. For either type of line operation, connect the printer according to paragraph 16e and turn the LOCAL switch to position 1.

18. TERMINAL-TO-TERMINAL WITH REPEATER TG-31 (INTERMEDIATE), (FIG. 10).

Operation with Repeater TG-31 (Intermediate) requires that both terminal repeaters be arranged as polar-sending repeaters (LINE switch in position 1), and the line current is adjusted at both terminal repeaters. The LOCAL switches should be turned to suit the local connection used; position 1, for example, if a printer is used.

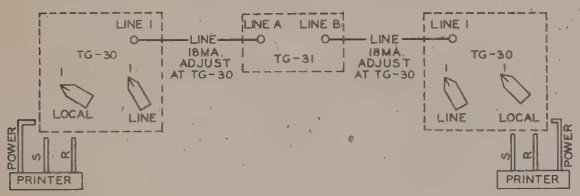


Figure 10 - Terminal-to-terminal with Printer and with Repeater TG-31 (Intermediate)

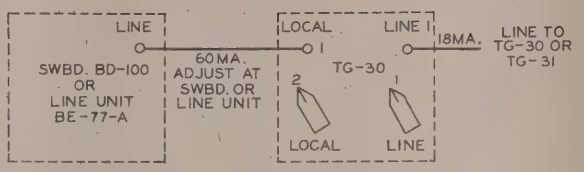


Figure 11 - Local Operation with Switchboard BD-100 or Line Unit BE-77 or BE-77-A

19. LOCAL OPERATION WITH SWITCHBOARD BD-100 OR LINE UNIT BE-77 OR BE-77-A (FIG. 11).

Turn the LOCAL switch to position 2 and connect LOCAL binding post 1 on the repeater to a LINE terminal in the switchboard or to the LINE terminal on the line unit. The power for the local circuit is furnished by the switchboard or line unit. Adjust local current to 60 milliamperes by using the rheostat in switchboard line circuit or the rheostat in the line unit. Throw keys in the line unit to RELAY IN CIRCUIT and to LOCAL CURRENT SUPPLY. Connect the line unit power cord to its rectifier so as to furnish negative 115 volts to the LINE terminal connected to Repeater TG-30. The preferred position for the LINE switch of Repeater TG-30 is polarential, polar sending (position 1) or 2-path polar (position 3). However, if necessary, the repeater may be operated with the LINE switch for polarential, differential sending (position 2). Furthermore, better reception will be obtained at the switchboard if the receiving relay WEST is adjusted spacing using the switchboard local bias test circuit. Determine the amount of spacing bias by test. The LINE switch must be turned to position 1 if a Repeater TG-31 is used at an intermediate point. The meter on Repeater TG-30 is a line-open signal when the LINE switch is in position 1 for polarential, polar sending operation or position 3 for 2-path polar operation (sending line only). When no current flows in the line the meter indicates zero.

20. LOCAL OPERATION WITH TELEGRAPH TERMINAL CF-2-( ), (CARRIER), (FIG. 12).

Turn the LOOP switch in the carrier terminal to NEUTRAL TO NEG BAT - HALF DX, and the LOCAL switch in Repeater TG-30 to position 3. Connect wires from LOCAL binding posts 1 and 2 of the repeater to the binding posts SL and RL, respectively, of a telegraph terminal channel in CF-2-( ) equipment. Adjust local current to 60 milliamperes using the potentiometer in the sending loop of the carrier equipment. The local current is indicated on the meter in the carrier terminal equipment. Operate the LINE switch in Repeater TG-30 to suit the form of line operation to be used.

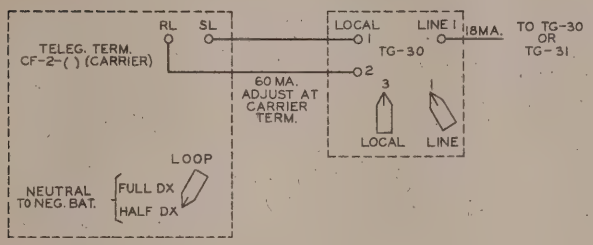


Figure 12 - Local Operation with Telegraph Terminal CF-2-( ), (Carrier)

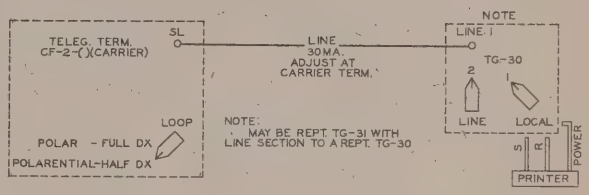


Figure 13 - Line Operation (Half Duplex) with Telegraph Terminal CF-2-( ), (Carrier)

21. LINE OPERATION (HALF DUPLEX) WITH TELEGRAPH TERMINAL CF-2-( ), (CARRIER), (FIG. 13).

Turn the LOOP switch in the carrier terminal to POLARENTIAL HALF DX and connect the line wire to the binding post SL in a CF-2-( ) channel terminal. Turn the LINE switch in Repeater TG-30 to position 2 and connect the line wire to LINE 1 binding post. Adjust the line current to 30 milliamperes at the carrier equipment. At Repeater TG-30, turn the LOCAL switch as required; position 1, for example, if a printer is used.

22. LINE OPERATION (FULL DUPLEX) WITH TELEGRAPH TERMINAL CF-2-( ), (CARRIER), (FIG. 14).

Line operation on a full-duplex basis requires the use of two Repeaters TG-30. At the carrier terminal, connections are established for 2-path polar operation. Each Repeater TG-30 is arranged for polarential operation (one as polar sending and one as differential sending). This provides two one-way polarential circuits (one circuit sends A to B and the other B to A). A printer is required with each Repeater TG-30. One printer serves as a receiving-only printer and the other as a sending printer which also produces a local copy. Turn LOOP switch at the carrier terminal to the POLAR -

FULL DX position. Connect the receiving line at the carrier terminal of the sending Repeater TG-30 to a binding post SL in the CF-2-( ) terminal. Connect the sending line at the carrier terminal of the receiving Repeater TG-30 to the associated binding post RL in the CF-2-( ) terminal. Turn the LINE switch to position 1 on the Repeater TG-30 which sends to the carrier terminal and adjust the line current at the repeater. Turn the LINE switch to position 2 on the repeater which receives from the carrier terminal. Adjust the line which sends from the carrier terminal to a line current of 30 milliamperes at the carrier equipment. Turn the LOCAL switches in both Repeaters TG-30 to position 1 for use with the printers.

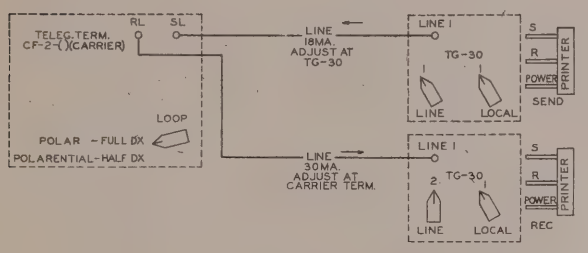


Figure 14 - Line Operation (Full Duplex) with Telegraph Terminal CF-2-( ), (Carrier)

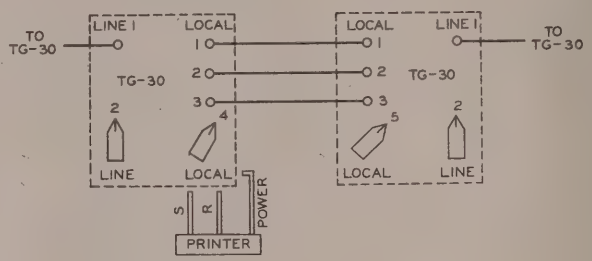


Figure 15 - Intermediate Operation with a Printer Using Two Repeaters TG-30

23. INTERMEDIATE OPERATION WITH A PRINTER USING TWO REPEATERS TG-30 (TERMINAL), (FIG. 15).

Two Repeaters TG-30 may be set up to provide intermediate operation and a printer may be connected to one of the repeaters if required. The printer will send simultaneously in both directions and receive from either terminal. Set the LINE switches on both repeaters for the same form of polarential line operation; that is, to position 1 or position 2. To be the equivalent of a Repeater TG-31 (Intermediate), both LINE switches should be turned to position 2. Connect the two repeaters locally by connecting LOCAL binding posts 1 to 1, LOCAL binding posts 2 to 2, and LOCAL binding posts 3 to 3. No local circuit adjustments are required. The printer may be connected to one of the repeaters and the LOCAL switch of this repeater must be turned to position 4. The LOCAL switch of the other repeater must be turned to position 5.

24. LOCAL OPERATION WITH REPEATER TG-29-( ), (ELECTRONIC, REGENERATIVE), (FIG. 16).

Repeater TG-29-( ) can be used in combination with one or two Repeaters TG-30. Arrange Repeater TG-29 for neutral operation. Turn the LINE switch

of Repeater TG-30 as required for line circuit operation. Connect the binding posts LOCAL 1 to 2 LINE A, and LOCAL 2 to 1 LINE A of one Repeater TG-30, and connect binding posts LOCAL 1 to 2 LINE B and LOCAL 2 to 1 LINE B of other Repeater TG-30, if employed. Turn the LOCAL switch on each Repeater TG-30 to position 5. Adjust the current to 30 milliamperes in the local circuits to Repeaters TG-30 by use of potentiometers in Repeater TG-29-( ). ›eter to show this current is furnished in Repeater TG-29-( ).

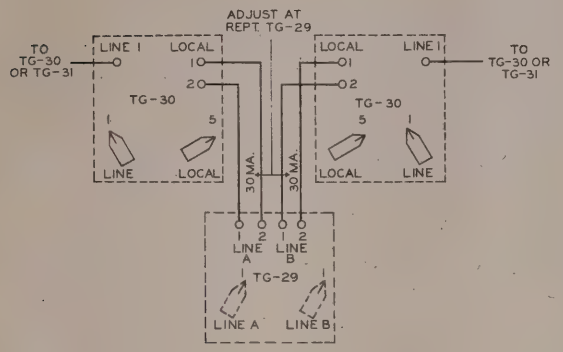


Figure 16 - Local Operation with Repeater TG-29-( ), (Electronic, Regenerative)

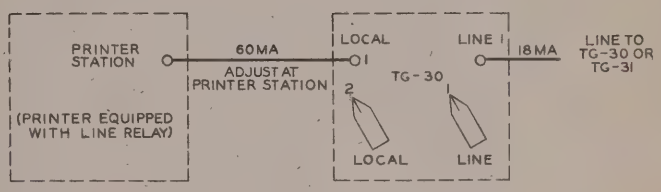


Figure 17 - Local Operation to a Printer Equipped with a Line Relay

25. LOCAL OPERATION WITH A PRINTER STATION (FIG. 17).

The printer at the station should be equipped with a line relay and the polar-neutral key operated to neutral. A variable 2000-ohm resistance should be employed in series in the line at the station and the line current adjusted to 60 milliamperes. Adjust the station rectifier to 120 volts when the line is closed and the printer magnet connected. The bias current of the line relay in the station should be 30 milliamperes. Connect the line wire to LOCAL 1 binding post at Repeater TG-30 and turn the LOCAL switch to position 2. The preferred position for the LINE switch is polarential, polar sending (position 1).

26. TWO-PATH POLAR LINE OPERATION (FIG. 18).

Line operation on a 2-path polar basis is half duplex and may be used with a distant Repeater TG-30 or an equivalent 2-path polar termination. The receiving relay in Repeater TG-30 is connected to hold the local circuits closed when the marking polarity of the distant terminal is negative. Connect the sending line to the LINE 1 binding post and connect the receiving line to the LINE 2 binding post. Turn the LOCAL switch as required.

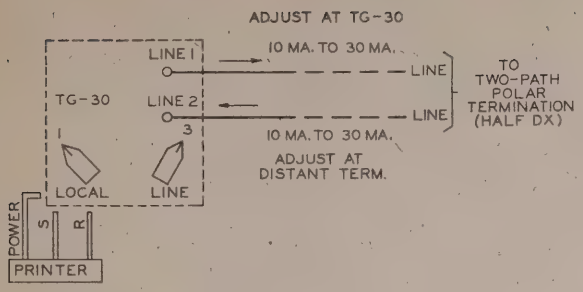


Figure 18 - Two-path Polar Line Operation

27. MANUAL TELEGRAPH SET.

Turn the LOCAL switch to position 1 for manual telegraph operation and disconnect all printer cords. The power used for operating the repeater on printer circuits is required also for manual telegraph operation and all forms of line operation are usable with manual telegraph operation. Connect the telephone receiver to jack designated HEADSET. Hold down the telegraph key and adjust the tone heard in the telephone receiver to suit by turning knob designated ADJ TONE. When distant terminal is using a printer, send a number of long dashes as a signal that manual telegraph operation is desired. The printer runs open while the telegraph key is held down.

28. CONNECTING POWER CORD AND ADJUSTING VOLTAGE AND LINE CURRENT.

a. Power Cord.—Connect power cord to the power source.

b. Adjusting Voltage on D-C Supply.—When d-c power (gas-engine power unit) supply is employed, regulate the voltage to 115 volts at the source, and connect the power cord so that meter on Repeater TG-30 reads to the right of zero when the MEAS VOLTS key is held down. Reverse power cord if meter reads to the left of zero.

c. Adjusting Voltage on A-C Supply.—When a-c power is used, hold down the MEAS VOLTS key and turn ADJUST VOLTS knobs designated COARSE and FINE until meter indicates 115 volts. This point is designated by a red line on the meter.

d. Adjusting Line Current.

(1) Polarential Operation.—Line current is adjustable at a repeater set up for polarential polar sending (LINE switch in position 1). If the meter shows zero, the line may be open or the distant terminal not connected for service. After the voltage has been adjusted and with ADJ LINE CURRENT switch in maximum counterclockwise (to the left) position (refer to par. 16f) turn the ADJ LINE CURRENT knob FINE to the maximum INCREASE position and the ADJ LINE CURRENT knob COARSE clockwise (to the right) to the first position which gives at least 18 milliamperes. Turn the ADJ LINE CURRENT knob FINE as required to give a line current of 18 milliamperes. Request the distant point to send a break signal for about 10 seconds by holding down break key of printer or otherwise sending a long spacing signal. Read the spacing

line current. If it is not 44 to 46 milliamperes, readjust in accordance with Table II, taking into consideration the types of lines as shown. Any lineup subsequent to starting service should be made in accordance with Table II. If the lineup requires a readjustment of line current on a space from the distant point, the marking line current will exceed 18 milliamperes.

TABLE II

Spacing Line Current	Readjust Spacing Line Current to be		
	104 mil Copper-steel and Field Wire	104 mil Copper	80 mil Copper-steel
44 to 46 MA	No change	48 MA	44 MA
42 to 43	44	46	43
40 to 41	43	45	42
38 to 39	42	44	42
36 to 37	41	43	41
34 to 35	40	41	40
32 to 33	39	39	40
30 to 31	38	38	39
28 to 29	37	37	38
26 to 27	36	36	38

(2) Two-path Polar Operation.—The line current is adjustable in the sending line only at Repeater TG-30. Adjust the receiving line current at Repeater TG-30 in the sending line of the distant terminal repeater. Turn the ADJ LINE CURRENT knobs COARSE and FINE to give the highest line current obtainable with the line facility used but the line current should not exceed about 30 milliamperes.

SECTION III
FUNCTIONING OF PARTS

29. REPEATER LINE CIRCUIT OPERATION.

a. General.—In the case of polarential (polar sending) and 2-path polar operation, the transmitting branch of the repeater is arranged for double commutation to permit sending negative and positive battery from a single nongrounded power supply. Two sending relays are needed for this type of transmitting branch. The reversal of polarity takes place across the portion of a potentiometer circuit which provides 75 volts for marking and 75 volts for spacing (refer to figs. 19 and 21). Transmission from a repeater arranged for differential-sending uses one of the relays for sending. The other relay holds the receiving relay on marking on outgoing signals. (Refer to fig. 20.) The PROT BLOCKS serve to protect the equipment on line surges. FILTER A is a radio-suppression filter. RET COIL A is a telephone noise-killer coil. For descriptive purposes in this section, polarential (polar sending) line operation has been shown schematically with local circuit arrangements. Refer to paragraph 11 for circuit schematic of polar relays. For detail circuit schematic drawing, refer to figure 38.

b. Line Side of Repeater Operating Polarential, Polar Sending.—Figure 19 shows in schematic form the line side of the repeater when the LINE switch is in position 1. The ADJ LINE CURRENT switch designated COARSE

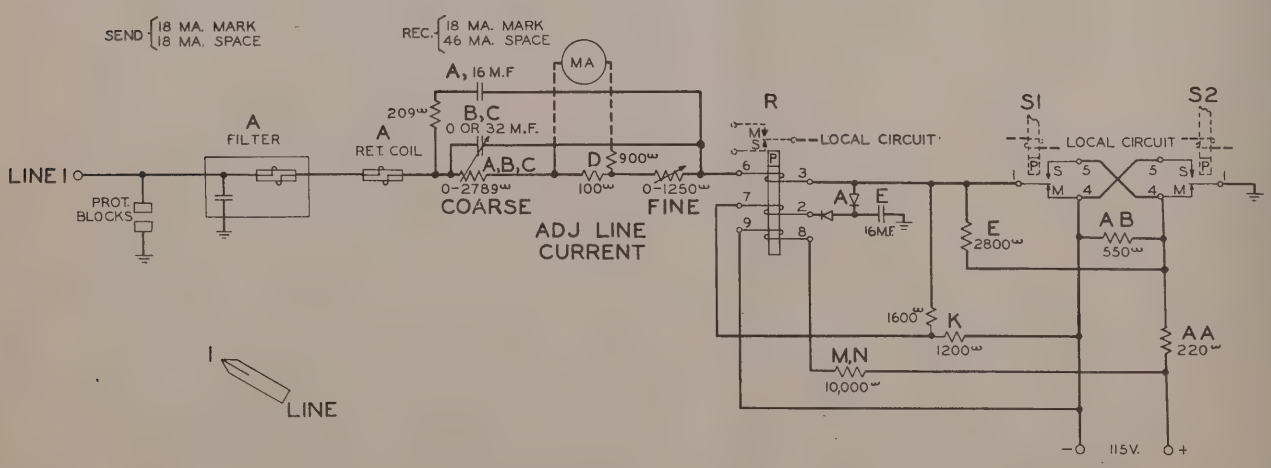


Figure 19 - Schematic of Line Side of Repeater Operating Polarential, Polar Sending

controls series resistance with shunted capacity to provide wave shaping and at the same time an approximate adjustment of the line current. The final value of line current is obtained by turning the ADJ LINE CURRENT potentiometer (0-1250 ohms) designated FINE. In the idle condition, the receiving relay R is held on marking M due to approximately 10 milliamperes in the bias winding 9-8. When the sending relays S1 and S2 operate from the local circuit, negative and positive 75 volts is applied alternately to the line, resulting in a reversal of line current for the marking and spacing conditions. The 115-volt supply is reduced to 75 volts by a potentiometer circuit consisting of a series resistor AA and a shunt resistor AB. Varistor A, in combination with capacitor E, and relay winding 7-2 form an antikick circuit which holds the receiving relay on marking during outgoing transmission. Discharge of the line capacity, especially on wet field wire circuits, tends to kick the receiving relay to spacing on outgoing signals. Resistor K terminates the 2-7 winding of relay R in a suitable impedance and provides for the application of suitable voltages during marking and spacing impulses to insure proper functioning of the antikick circuit. Resistor E provides a load during a spacing impulse to aid in regulating the voltage output of the rectifier. When signals are received from a distant terminal, the line current increases on spacing impulses (same direction as idle marking current) from 18 milliamperes to about 46 milliamperes on a dry line. This causes operation of the receiving relay by overcoming the effect of the bias current of 10 milliamperes (equivalent to 30 milliamperes for 90-ohm line winding). As the effective bias current is approximately midway between the marking and spacing line currents, incoming transmission, therefore, affects the armature of the receiving relay equivalent to a reversal of line current. Operation of the receiving relay actuates the local circuit.

c. Line Side of Repeater Operating Polarential, Differential Sending.— Figure 20 shows in schematic form the line side of the repeater when the

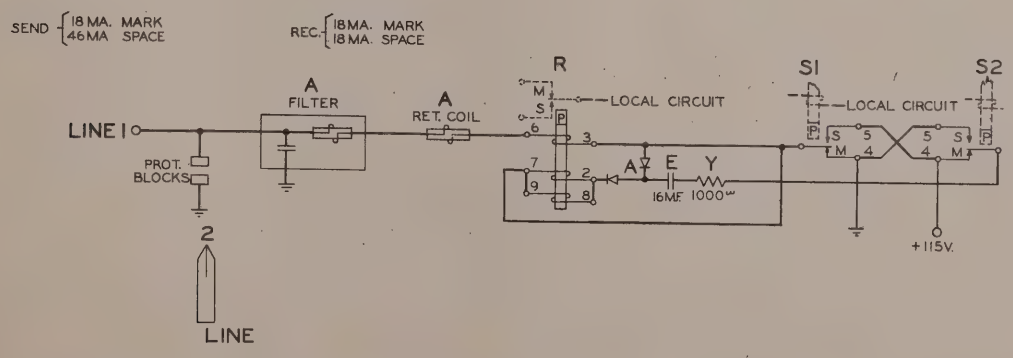


Figure 20 - Schematic of Line Side of Repeater Operating Polarential, Differential Sending

LINE switch is in position 2. The line current is not adjustable at a repeater which is operating differential sending. In the idle condition, the receiving relay is held on marking due to line current furnished from distant terminal. When the sending relay S1 operates from the local circuit, ground and positive 115 volts is applied alternately to the line for marking and spacing respectively. Varistor A in combination with capacitor E, resistor Y, and contacts of relay S2 constitute the antikick circuit. When signals are received from a distant terminal, the receiving relay R operates on current reversals of equal value.

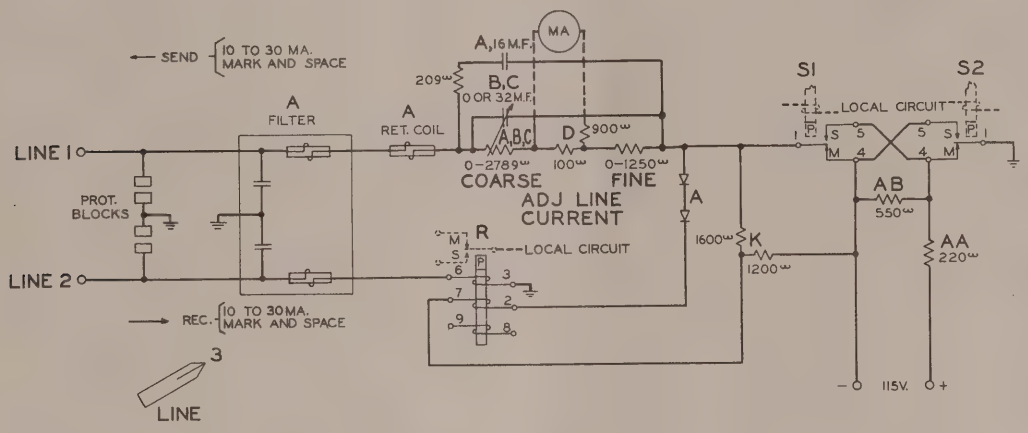


Figure 21 - Schematic of Line Side of Repeater Operating 2-path Polar

d. Line Side of Repeater Operating 2-path Polar.—Figure 21 shows schematically the line side of the repeater when the LINE switch is in position 3. Signals are transmitted over the line connected to the LINE 1 binding post to the distant terminal, and signals are received from the distant terminal over the line connected to the LINE 2 binding post. The ADJ LINE CURRENT switch designated COARSE and the potentiometer designated FINE permit an adjustment of the line current in the line connected to binding post LINE 1. The line current is adjustable only in the sending line. In the idle condition, the receiving relay R is held on marking by current flowing through line winding 3-6. (Marking polarity from distant terminal must be negative.) When the sending relays S1 and S2 are actuated from the local circuit, negative 75 volts is applied to the line for marking and positive 75 volts for spacing. Varistor A, in combination with winding 7-2 of relay R and resistor K, provides a locking circuit to hold the receiving relay on marking when signals are being sent from the repeater. This holding circuit provides a communication break feature. Incoming signals from the distant terminal are current reversals of equal value, the magnitude of which is determined by the line current adjustment at the distant terminal.

30. REPEATER LOCAL CIRCUIT OPERATION.

a. General.—The local side of the repeater is arranged for connections to printers with separate sending and receiving circuits, to 30- or 60-milliampere neutral loops, and for intermediate operation with another Repeater TG-30.

b. Local Operation with Printer TG-7-( ).—Figure 22 is a complete functional schematic showing the repeater and rectifier power circuit with

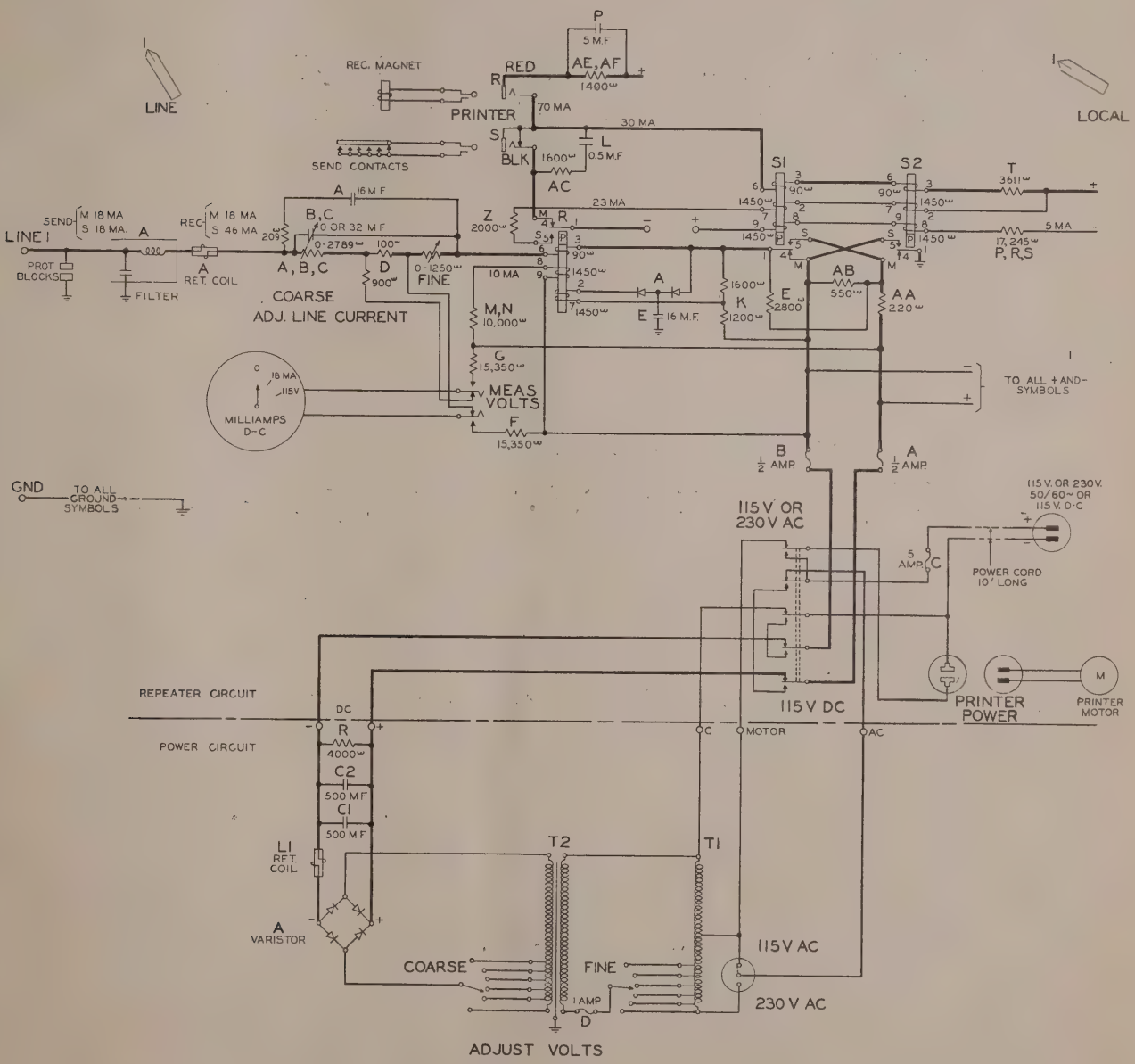


Figure 22 - Functional Schematic of Repeater and Power Circuit Repeater Circuit with Printer

the line side arranged for polarential, (polar sending, LINE switch in position 1) and the local side connected to a printer (LOCAL switch in position 1). Figure 23 shows schematically the local side of the repeater when the LOCAL switch is in position 1. When idle, the sending relays S1 and S2 are held marking due to about 30 milliamperes in the 3-6 winding, and the printer magnet is operated by a current of about 70 milliamperes. Operation of the sending contacts opens the magnet circuit to produce local copy. The line windings 3-6 of the sending relays are opened also by the printer sending contacts, and these relays are operated to space due to current through bias windings 8-9 when the 3-6 windings are opened. On incoming signals, the

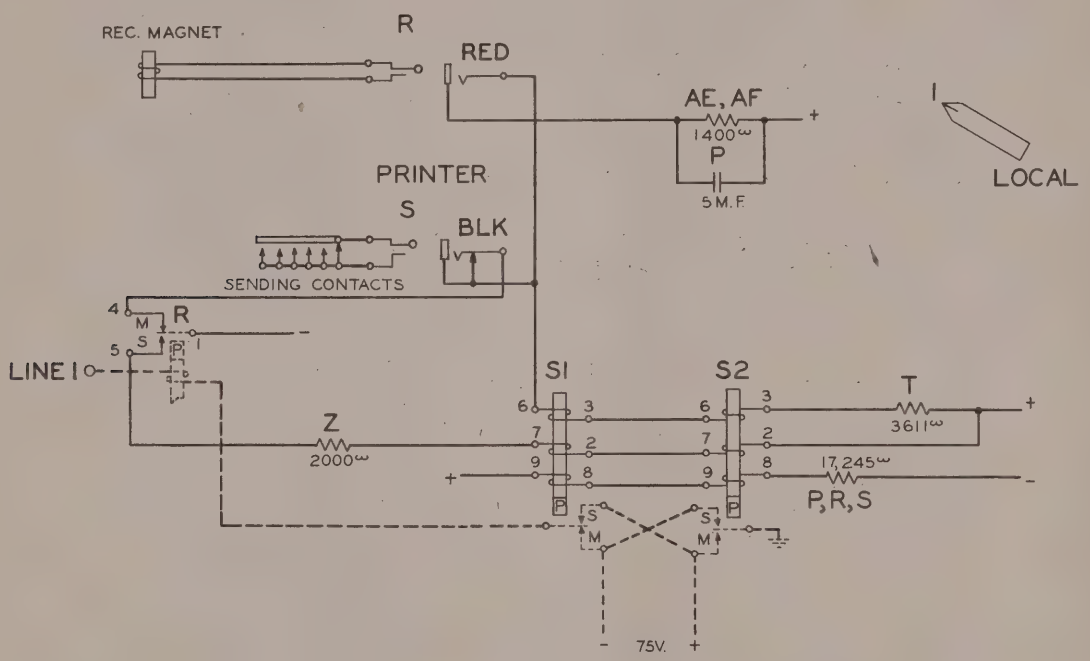


Figure 23 - Schematic of Local Side of Repeater Operating with Printer TG-7-( )

receiving relay R removes negative 115 volts from the magnet circuit, thereby causing the receiving magnet of the printer to function. The sending relays are held marking when the receiving relay is spacing due to the application of negative 115 volts via current limiting resistor Z and windings 2-7. This hold circuit provides a communication break feature. Resistor T and resistors P, R, and S limit the current to the required value for the 3-6 windings and 9-8 windings, respectively. Resistors AE and AF shunted by capacitor P limit the current as required for the receiving magnet and provide wave shaping. Resistor AC and capacitor L (fig. 22) are a spark killer for the sending contacts of the printer.

c. Local Operation with Switchboard BD-100.—Figure 24 shows schematically the local circuit of the repeater when the LOCAL switch is in position 2 and when LOCAL binding post 1 is connected to a LINE terminal in the Switchboard BD-100. In the idle condition, the sending relays S1 and S2 are held marking by approximately 30 milliamperes through windings 3-6. This current is furnished from the negative 115-volt supply used in connection with the switchboard. The local current is adjusted to 60 milliamperes by a line potentiometer in the switchboard. This 60 milliamperes divides about equally through resistors H and L, thereby providing a current of about 30

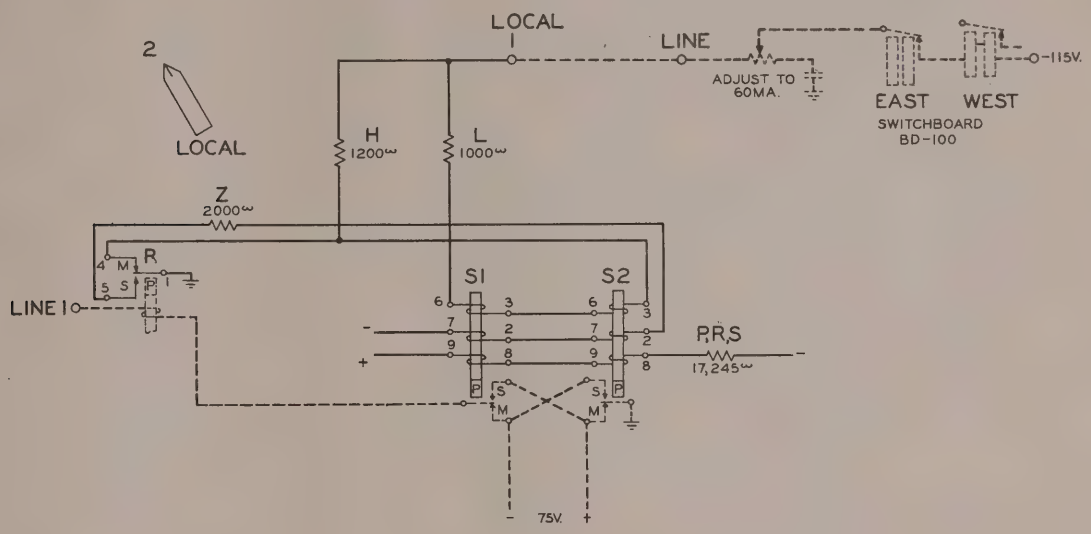


Figure 24 - Schematic of Local Side of Repeater Operating with Switchboard BD-100

milliamperes through windings 3-6 of the sending relays. When switchboard sending relay EAST is released, current is removed from line windings 3-6 of relays S1 and S2, and these relays transmit signals to the line. On incoming signals, the receiving relay R removes ground from the local circuit and opens the circuit to the switchboard, thereby causing the release of receiving relay WEST. Windings 2-7 of relays S1 and S2 with resistor Z provide a circuit to hold the sending relays on marking when spacing signals are being received by relay R. Relay windings 9-8, in combination with resistors P, R, and S, provide the local bias circuit.

d. Local Operation with Line Unit BE-77 or BE-77-A.—Figure 25 shows schematically local circuit operation with the LOCAL switch in position 2 and LOCAL binding post 1 connected to the LINE terminal of a Line Unit BE-77 or BE-77-A. The operating features and local current adjustments are iden-

tical to operation with Switchboard BD-100. (Refer to par. 30c.) The relay in the line unit responds to incoming signals repeated by receiving relay R, and the sending contacts of the printer connected to the line unit opens and closes the windings 3-6 of the sending relays S1 and S2, which transmit to the line circuit.

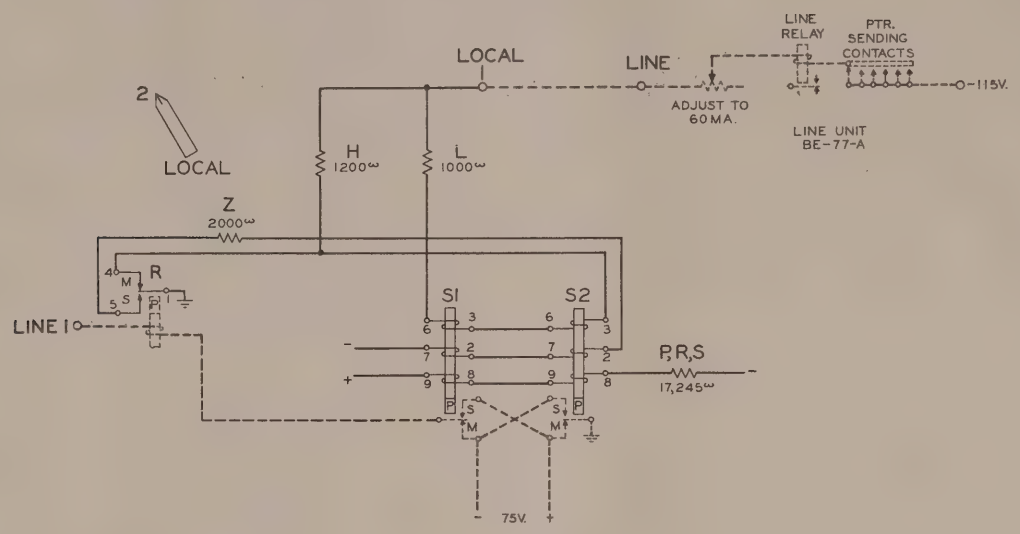


Figure 25 - Schematic of Local Side of Repeater Operating with Line Unit BE-77 or BE-77-A

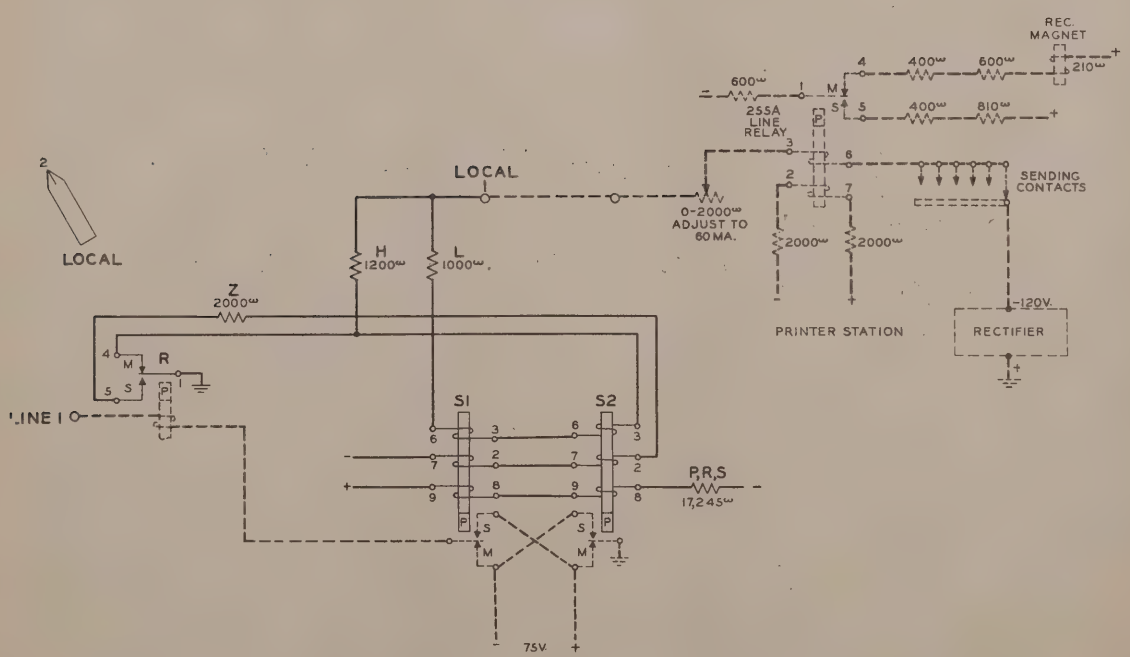


Figure 26 - Schematic of Local Side of Repeater Operating with Printer Station

e. Local Operation with a Printer Equipped with a Line Relay.—Figure 26 shows schematically the local side of the repeater connected to a station in which the printer is equipped with a line relay with a 30-milliampere bias current. The printer station should have an adjustable resistance (0-2000 ohms) added in series in the line to permit a line current adjustment to 60 milliamperes. Adjust the printer station rectifier for 120 volts when the line is closed and the printer magnet connected. Operation of the receiving relay in the Repeater TG-30 opens and closes the station line and the bias current (30 milliamperes) in the line relay in the station causes its operation to spacing when the line is open. The line relay actuates the printer magnet. Sending from the printer opens and closes the line and causes operation of relays S1 and S2 (3-6 windings) which transmit from Repeater TG-30. The printer line relay responds to outgoing signals to produce local copy.

f. Local Operation with Telegraph Terminal CF-2-( ), (Carrier).—Figure 27 is a schematic of the local circuit of the repeater with the LOCAL switch in position 3 and wires connected from LOCAL binding posts 1 and 2 to SL and RL binding posts of a CF-2-( ), (Carrier) channel terminal. The LOOP switch in the carrier equipment is turned to NEUTRAL TO NEG BAT - HALF DX. The local current is adjusted to 60 milliamperes by the potentiometer in the

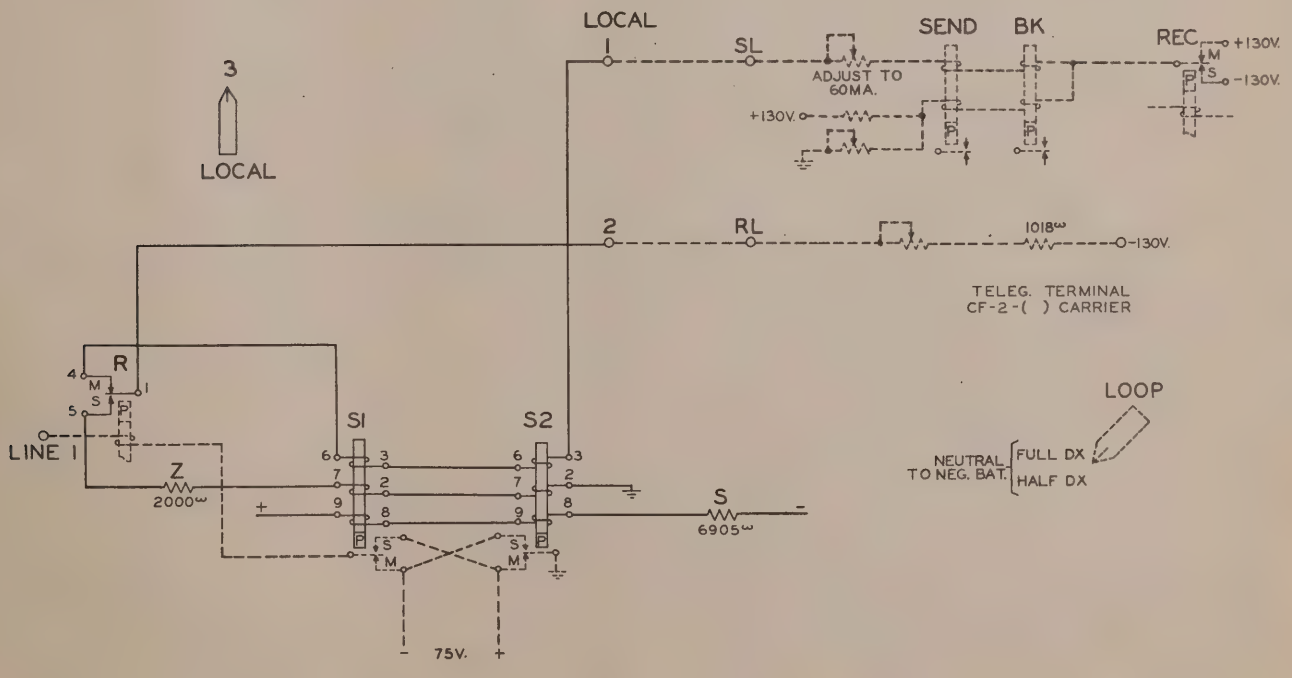


Figure 27 - Schematic of Local Side of Repeater Operating with Telegraph Terminal CF-2-( ), (Carrier)

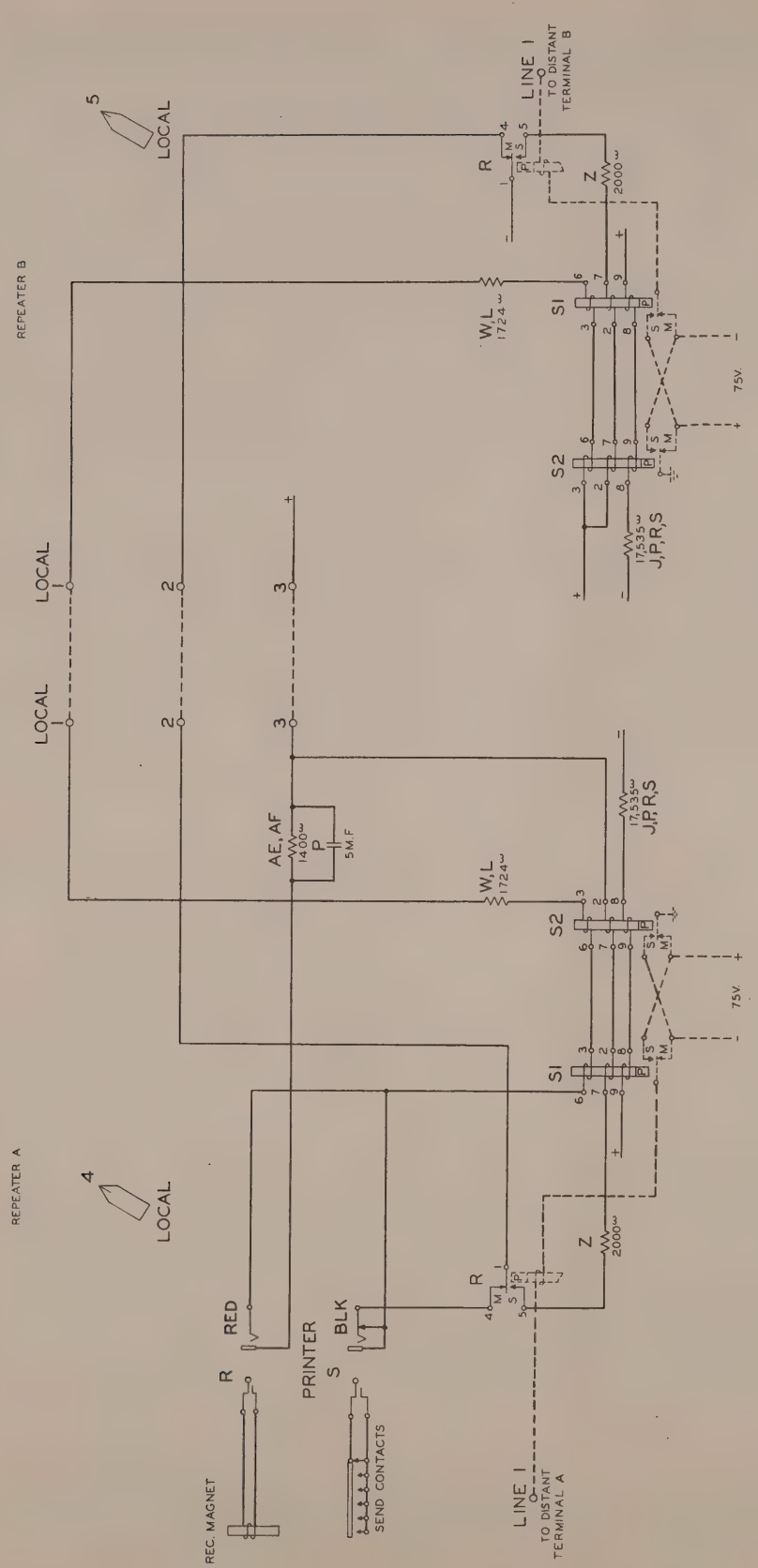


Figure 28 - Schematic of Local Circuits of Two Repeaters Providing Intermediate Operation with a Printer

carrier equipment, and the current is indicated by a meter. In the idle condition, the 60-milliampere local current flows from positive 130 volts at contact M of REC relay, through the SEND and BK relays in the carrier equipment, binding posts SL and LOCAL 1, windings 3-6 of relays S1 and S2, marking contact M of relay R, and binding posts LOCAL 2 and RL to negative 130 volts in the carrier equipment. Operation of the relay REC in the carrier equipment causes operation of relays S1 and S2 which send to the line circuit. On incoming line signals to the telegraph repeater, the receiving relay R opens and closes the local circuit and causes operation of the SEND and BK relays in the carrier equipment. The sending relays S1 and S2 are held marking on an incoming space due to the application of negative 130 volts in the carrier equipment via spacing contact of relay R, resistor Z, and windings 2-7 of the sending relays S1 and S2. Resistor S, in combination with windings 8-9 of the sending relays, provides a local bias current of about 10 milliamperes (equivalent to 30 milliamperes in a 90-ohm winding).

g. Local Operation Using Two Terminal Repeaters TG-30 to Provide Intermediate Operation.—Figure 28 shows schematically the local circuits of two Repeaters TG-30 arranged to provide intermediate operation with or without a printer. The LOCAL switch of the repeater to which the printer is connected must be in position 4, and the LOCAL switch of the other repeater must be in position 5. The LOCAL binding posts 1, 2, and 3 of one repeater are connected to binding posts 1, 2, and 3 respectively of the other repeater. These connections provide the proper local circuit current and hence, no local current adjustments are required. In the following description, the repeater connected to line to distant terminal A will be called repeater A and the one connected to the line to distant terminal B will be called repeater B. The local circuit closed condition includes the marking contact of relay R in repeater B, LOCAL binding posts 2, the marking contact of relay R in repeater A, the sending contacts of the printer, windings 3-6 of relays S1 and S2 in repeater A, resistors W and L in repeater A, LOCAL binding posts 1, resistors W and L in repeater B, and windings 3-6 of relays S1 and S2, repeater B. This produces a local circuit of about 30 milliamperes. The sending relays of each repeater have a local bias current of about 5 milliamperes produced by windings 8-9 and resistors J, P, R, and S. This 5 milliamperes is equivalent to 15 milliamperes in a 90-ohm winding.

(1) When terminal A is transmitting a space to terminal B, the receiving relay R repeater A, opens the local circuit, holds the associated relays S1 and S2 marking, and causes operation of relays S1 and S2 in repeater B, which retransmit to the line to terminal B. The receiving relay R, repeater A, responding to the incoming transmission also operates the receiving magnet of the printer due to removal of negative 115 volts being applied at armature of receiving relay in repeater B. This provides a copy at the inter-

mediate point. The receiving magnet closed circuit involves the marking contact of relay R in repeater B, and LOCAL binding posts 2, marking contact relay R, repeater A, sending contacts of printer, printer magnet, resistors AE and AF, LOCAL binding posts 3 to the positive side of the power supply.

(2) When terminal B transmits a space to terminal A, the receiving relay R in repeater B, operates and opens the local circuit, holds its associated sending relays marking, causes operation of the relays S1 and S2 in repeater A, and the printer magnet.

(3) Sending from the printer opens and closes the local circuit which causes operation of sending relays S1 and S2 in both repeaters but does not cause the operation of either receiving relay. Relays S1 and S2 send to their associated line circuits; that is, sending is simultaneous to terminal A and terminal B. The sending contacts of the printer also control the receiving magnet circuit to produce local copy.

h. Local Operation with Repeater TG-29-( ), (Electronic, Regenerative).—Figure 29 shows schematically the local circuit of a repeater with LOCAL switch in position 5 and wires connected from LOCAL binding posts 1 and 2 to Repeater TG-29. A second Repeater TG-30 may be connected to Repeater TG-29, and it is arranged for operation in the same manner as the one shown in figure 29 except that the local wiring is to the LINE B binding posts 1 and 2 on Repeater TG-29. The local circuits are adjusted for 30 milliamperes by using the potentiometers (one associated with line A and one associated with line B) in Repeater TG-29. The local circuit operation is

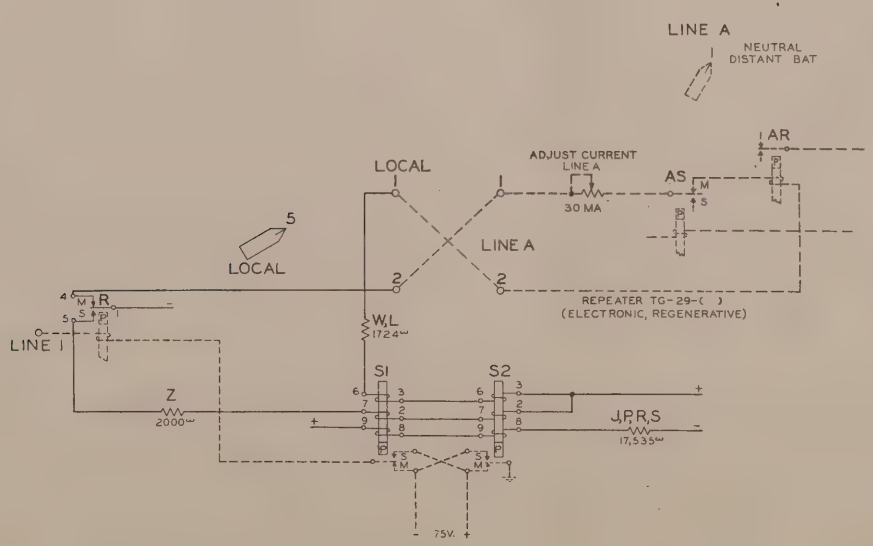


Figure 29 - Schematic of Local Side of Repeater Operating with Repeater TG-29-( ), (Electronic, Regenerative)

neutral. In the marking condition this involves in Repeater TG-30 the negative side of the power supply at contact M of relay R, LOCAL binding posts 1 and 2, resistors W and L, and windings 3-6 of relays S1 and S2 to the positive side of the power supply. On the "line A" side of Repeater TG-29 the circuit involves the line current adjusting potentiometer contacts of sending relay AS, line windings of receiving relay AR, and binding posts 1 and 2 LINE A. The local circuit is identical for the other Repeater TG-30, which may be connected to the line B side of Repeater TG-29. Incoming line signals from a distant terminal A for example, operate the associated receiving relay R, which opens the local circuit and operates receiving relay AR in the regenerative repeater. The line signals are retimed and retransmitted by the regenerative repeater and operate the sending relay BS (not shown in sketch) on the line B side of the regenerative repeater. This sending relay in turn opens the local circuit of the associated Repeater TG-30, if used, thereby causing its sending relays to retransmit to the line circuit to distant terminal B. Resistors J, P, R, and S, in combination with windings 8-9 of relays S1 and S2, provide a bias current of about 5 milliamperes (equivalent to 15 milliamperes for a 90-ohm winding). Resistor Z with windings 2-7 of the sending relays provides a holding circuit to retain the sending relays on marking when the receiving relay operates.

31. RECTIFIER POWER CIRCUIT OPERATION.

The rectifier power circuit is shown schematically as part of figure 22 and in detail in figure 30. The voltage applied to the autotransformer T1 is controlled by the 115V AC - 230V AC switch. In the 115V AC position, the power-supply voltage is applied to the lower portion of the winding and in the 230V AC position the power-supply voltage is applied to the total winding. In both cases, the voltage applied to the primary of transformer T2 is controlled by a multicontact switch which selects taps fine on the autotransformer. The secondary of transformer T2 is supplied with coarse taps, which

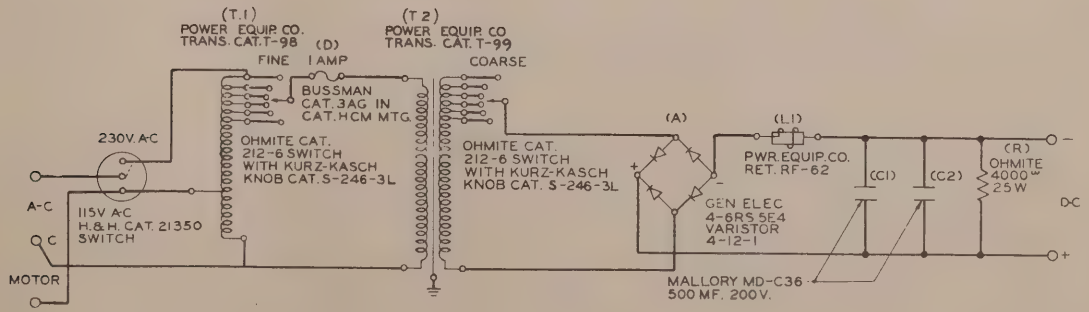


Figure 30 - Schematic, Rectifier Power Circuit

are controlled by a multicontact switch. By turning the FINE and COARSE switches designated ADJUST VOLTS, the voltage applied to the varistor A is adjusted to provide an output of 115 volts d-c. The midpoint tap on the autotransformer provides a 115 volts a-c for the printer motor when the power supply is 230 volts a-c. The selenium-disc rectifier converts alternating current to direct current and it is a full-wave rectifier. Retardation coil L1, capacitors C1 and C2 serve as a filter to reduce the ripple. The resistor R is an artificial load and aids in producing the required voltage regulation characteristics.

32. MANUAL TELEGRAPH SET CIRCUIT OPERATION (FIG. 31).

The manual telegraph circuit uses the sending and receiving features of Repeater TG-30. It becomes operative when the LOCAL switch is in position 1, the printer cords removed, and the headset cord connected to the headset jack. The telegraph key is connected in the circuit when the printer sending cord is removed. The signal (tone heard in telephone receiver)

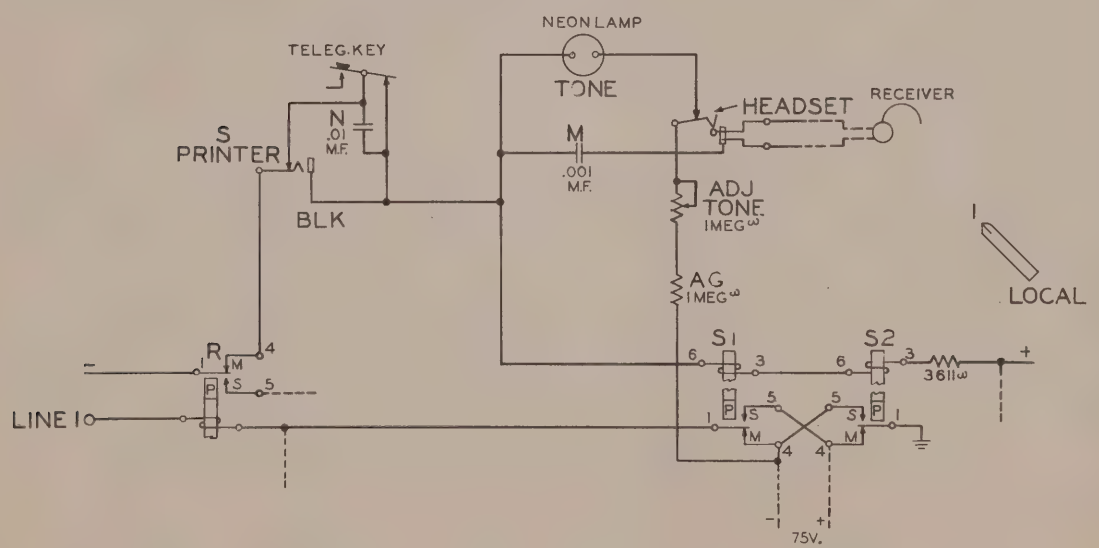


Figure 31 - Schematic of Manual Telegraph Set (Part of Repeater TG-30)

occurs when the telegraph key is held down. The sending is from the back contact of the telegraph key. This tone results from an oscillating circuit consisting of a small neon lamp TONE, capacitor M, resistor AG, and a one-megohm potentiometer ADJ TONE in combination with the receiver. The oscillating frequency may be varied over a wide range by adjusting the ADJ TONE potentiometer. In the idle condition, the negative side of the power supply is applied to the circuit at the marking contacts of relays S1 and R, and

no oscillations occur. When the telegraph key is operated the sending relays S1 and S2 are operated, and positive and negative sides of the power supply are applied to the circuit. The tube oscillates thereby producing a tone in the receiver. When the receiving relay responds to incoming line signals, the negative side of the 115-volt supply is removed from contact M of relay R and the tube oscillates due to the application of the positive and negative sides of the power supply.

SECTION IV
MAINTENANCE

33. SERVICE TESTS AND INSPECTIONS.

a. General.—While the repeater equipment continues to function satisfactorily, no maintenance work is necessary other than occasional checks and adjustments of the polar relays (par. 33b), restoration of the film on the electrolytic capacitors in the rectifier power unit (par. 33c), and cleaning the line protector blocks (par. 33d).

b. Polar Relays and Use of Relay Test Set I-193-A.

(1) Testing and Adjusting Polar Relays.—Adjust and test the polar relays by using Test Set I-193-A. Operation of this test set and the methods for testing maintaining, and adjusting polar relays is covered in the Technical Manual pertaining to Test Set I-193-A. The frequency of relay adjustments is a function of repeater usage. For this reason, it is impractical to establish a specific relay maintenance period. As a guide, however, it can be assumed that in 24-hour-a-day service, a relay should be checked in the test set and adjusted as required about every 30 days. When the service is in the order of a few hours per day, the relay should operate properly for many months. There is no change in the adjustment of the relay while it is idle and connected in a circuit or while it is in storage. To remove a relay from the repeater, turn the relay compartment fasteners (fig. 32) counterclockwise (to the left), lift cover and pull relays straight upward by using knurled thumbscrew on top of relay.

(2) Use of Test Set I-193-A with Repeater TG-30.—The rectifier power unit in Repeater TG-30 may be used as a source of d-c power for operation of Test Set I-193-A when the power source available is alternating current. A cord equipped with a gray-colored shell is supplied with the test set for patching to the battery supply TEST SET jack in Repeater TG-30. Connect the tip (white) conductor of the cord to +BAT, the ring (blue) conductor to -BAT, and the sleeve (red) conductor to GND binding post on the test set. Operate the LINE switch of Repeater TG-30 to position 2 in order to ground the negative side of the repeater power unit and operate the LOCAL switch to position 1. Connect ground to the GND binding post of the repeater and operate the power switches as covered in paragraph 16c. Adjust the voltage to 115 volts by turning the ADJ VOLTS knobs COARSE and FINE. Any or all of the relays may be removed from the repeater while it is supplying power for operating the test set. Refer to Technical Manual for Test Set I-193-A.

c. Electrolytic Capacitors.—Electrolytic capacitors C1 and C2 in the rectifier may lose their film if the equipment is held in storage or if it is operated on a d-c supply for a period of 18 months or longer. Replace these capacitors after 3-1/2 years from the date stamped on the case whether or not the equipment is in service. Normal operation on a-c power will maintain the capacitors in the proper operating condition. To restore the film, connect the power cord of the repeater to an a-c supply for at least 30 minutes every 18 months. If an a-c supply is not available, a source of 96 to 120 volts d-c with 110/120-volt lamp (25 to 100 watts) in series may be connected to the positive and negative terminals of the power unit for at least 30 minutes every 18 months. Connect the positive side of this lamp circuit to the +DC terminal and the negative side to the -DC terminal on power unit terminal block. To make a connection to these terminals, remove the power unit cover. Refer to figures 30 and 36.

d. Line Protectors.—Make periodic checks of the line protectors to determine that the carbon blocks are smooth and not pitted and that the assembly is free from dust and dirt. The LINE 1 and LINE 2 and spare protectors are shown in figure 34. The required maintenance period is largely a function of the exposure of the line circuit to high-voltage surges such as lightning. An inspection is recommended after every lightning storm in the area. In any case, they should be examined about every 30 days. The protectors are held in place by a flat spring and are readily removed by hand. Do not use pliers or any tool for removing or replacing the blocks. Wipe the carbon block and the porcelain block including the carbon insert with a clean cheesecloth. Discard any cracked or pitted blocks and any which can not be wiped smooth. Do not rub blocks together and do not use a file or abrasive.

34. PROCEDURE FOR LOCATING TROUBLE WITH REPEATER IN SERVICE.

a. General.—Improper operation may be caused by trouble in the repeater unit, the rectifier power unit, the printer, or the source of power supply. When trouble occurs in service, the following procedure is recommended. This procedure does not require removing the equipment from the carrying case and makes use only of the meter supplied with the equipment and in some cases ordinary 115-volt lamps.

b. Failure to Obtain Voltage.—Hold down the MEAS VOLTS key and check the voltage. This makes an over-all check of the power source and the power unit in the equipment. Readjust the voltage to 115 volts, if possible. In case no voltage reading is obtained, check all fuses, the power supply, and the connections to the power supply. Refer to paragraph 34e for fuse chart. When operating on direct current, the meter measures the output voltage of the power supply and when operating on alternating current, it measures the

d-c output of the rectifier in the power unit in the equipment. An approximate check of the a-c voltage may be made with 115-volt lamps (two in series for 220-volt supply) in case an a-c voltmeter is not available. If the equipment has been operating on an a-c source and the power unit in the repeater is found to be in trouble, it may be well to obtain a d-c gas-engine Power Unit PE-77-( ) or equivalent. If this is done, operate the power switch on the repeater to 115V DC and adjust voltage to 115 volts external to the equipment.

c. Failure to Obtain Line Current.—Read the meter to check the line current which is normally 18 milliamperes marking for polarential operation (LINE switch in position 1) and between 10 and 30 milliamperes in the sending line for 2-path polar operation (LINE switch in position 3). Refer to paragraph 28d for method of adjusting line current. The line current cannot be read on the meter in the repeater while the LINE switch is in position 2. If the voltage has been found to be correct and if the line current cannot be obtained by adjustment (LINE switch in position 1 and 3 only), it is probable that line trouble has developed or that troubles exist in the distant terminal. Before drawing this conclusion, check all binding post connections and the connection to ground. A high-resistance connection to ground may result in failure to obtain normal line current and in extreme cases may require the use of 2-path polar operation.

d. Checking Orientation Scale Setting of Printer.—The normal position for the orientation scale pointer is 50 to 55. Only in extreme emergency cases should the orientation of the printer be changed to compensate for improper functioning or improper adjustment of equipments. A local margin to check operation of the printer may be taken by operating the LINE switch to position 1. This holds the receiving relay on marking. The local margin, that is, the difference between the high and low readings should be at least 70 points. RESTORE THE RANGE FINDER to the normal position after the local margin has been taken.

e. Replacing Fuses.—The location of the fuses referred to in Table III are shown in figure 33. A spare fuse and fuse holder is provided on the panel for each type of fuse. Additional fuses unmounted are supplied in the fuse and lamp compartment in the cover. To replace a fuse, disconnect power cord, unscrew cap, and extract the fuse with the cap. Insert new fuse in the fuse holder and replace the cap.

f. Replacing Lamp in Manual Telegraph Set Circuit.—The oscillator (neon lamp), (fig. 33), designated TONE should light while the telegraph key is held down providing the printer cords are removed and the LOCAL switch is in position 1. This lamp is not brilliant and in sunlight it is advisable

TABLE III

FUSE CHART

Equipment Designation and Type	Location on Panel	Function	Circuit Designation
+1/2 AMP Bussman 8AG 1/2	Right side of meter	Fuses the positive lead to repeater circuit	A
-1/2 AMP Bussman 8AG 1/2	Right side of meter	Fuses the negative lead to repeater circuit	B
5 AMP Bussman MDM 5	Right side of PRINTER POWER receptacle	Main power-supply fuse	C
1 AMP Bussman 3AG 1	On rectifier power unit with ADJ VOLTS switches	Rectifier power-unit fuse	D

to shade the lamp while checking its operation. To replace the lamp, unscrew lamp cap and pull out the lamp. Spare lamps are located in the spare lamp and fuse compartment in the cover.

35. REMOVING REPEATER FROM SERVICE.

a. General.—Take a repeater, which cannot be made to work properly by procedures covered in paragraph 34, out of service and forward it to a repair station for testing.

b. Removing Unit From Carrying Case.—Disconnect all wires and cords. Loosen the four large round-head assembly screws designated in figure 33. These screws hold the basic framework of the equipment to the carrying case brackets. Lift the unit from the carrying case, using the side handles, and place it on a test bench.

c. Removing Rectifier Power Unit From Repeater Unit.—After removing the unit from the carrying case, loosen the two fasteners holding the rectifier power unit cover in place and remove the cover. Refer to figure 32. Disconnect the five wires attached to the power-unit terminal plate. Remove

the two round-head holding screws on each side bracket which mounts the power unit to the framework. The power unit may now be removed from the framework. When replacing these wires refer to color codes shown in wiring of circuits, figure 39.

36. TESTING FACILITIES AND EXPLANATION OF WIRING DIAGRAM.

a. General.—No special testing tools or facilities are required to follow the maintenance procedures outlined. A volt-ohmmeter may be used to measure a-c or d-c voltages and the resistance of resistors and to check capacitors for short-circuits or grounds. For this purpose use Volt-ohmmeter I-166 (part of Test Set I-56-K) or other available volt-ohmmeter having an internal resistance of at least 1000 ohms per volt.

b. Wiring Diagram.—A wiring diagram of the repeater circuit and the rectifier power circuit is shown in figure 39. In this diagram, each piece of apparatus has a letter designation corresponding to that shown on the wiring side; that is, the terminal side of each piece of apparatus. Each unit is shown in its relative location, as viewed from the wiring side. In this diagram, each piece of apparatus is arbitrarily assigned a number and lines called feed lines representing the individual wires are carried a short distance and terminated on a common or base line turning at right angles to the feed lines. These feed lines are marked with the color of the wire and have a number near the base line which is the same as the number of the piece of apparatus to which the other end of the wire is connected. It is not necessary to trace a connection through the common or base line and no provision is made for doing so. By observing the color and identification number, it is possible to trace directly to the other end of the wire. For example, by reference to J capacitor 76, a wire R134 is shown. This means a red wire is connected to 134. Resistor AD, which is 134, likewise indicates a red wire R76. Therefore, these are the two ends of the same wire, one end at capacitor J and the other end at resistor AD.

37. LOCATING TROUBLE WITH REPEATER REMOVED FROM SERVICE.

a. General.—In locating an unknown trouble the use of another Repeater TG-30 known to be in good condition will be useful. The two repeaters may be set up with a dummy line consisting of a resistance of 500 ohms. Two dummy lines are required for 2-path polar operation. These dummy lines will not provide a way for making transmission measurements because the dummy lines are not representative of real lines in regard to electrical characteristics. They will, however, permit communication between the two repeaters using printers or the manual telegraph sets and will provide a way

of checking the functions of the LINE switch positions. Local options other than the printer option may be checked by resistance or voltage drop measurements or continuity of wiring, using the volt-ohmmeter and a buzzer. Refer to Section V, "Trouble Location Information and Point-to-point Voltages and Resistance Measurements".

SECTION V
SUPPLEMENTARY DATA

38. TROUBLE LOCATION.

a. List of Troubles with Probable Cause.

Trouble	Probable Cause
(1) No line current with LINE switch in position 1 or position 3.	Line open or distant terminal not connected and supplying ground. Local power has failed. Connections broken at binding posts. Trouble in ADJ LINE CURRENT switch or potentiometer.
(2) High line current around 45 milliamperes at right of zero with LINE switch in position 1.	Spacing line current due to local circuit being open at distant terminal.
(3) Low line current	Distant terminal not connected and leakage present on line wire. Poor connections. Low power-supply voltage. High ground resistance.
(4) Line current steady at left of zero and equal to normal marking line current. LINE switch in position 1 or 3.	Space is being sent locally. Local loop is open and sending relays are spacing. D-c power supply reversed.
(5) Erractic line current.	Loose connections at distant terminal or at local repeater or in line wires.
(6) Errors on printed copy on incoming signals.	Incorrect voltage or current adjustment locally or at distant terminal. Printer in trouble. Orientation range finder not in correct position. Loose connections or poor jack or plug contacts on printer cords. Motor speed requires checking. Receiving relay may require readjustment.
(7) Errors on printed copy when sending locally.	Printer in trouble. Orientation range finder not in proper position.

Trouble	Probable Cause
	Receiving relay out of adjustment and "kicking-off" on outgoing signals. Sending relays out of adjustment. Poor jack or plug contacts on printer cords.
(8) No d-c voltage output.	Main fuse C (5 amp.) or power circuit fuse D (1 amp.) or positive or negative fuses A or B (+1/2 amp. or -1/2 amp.) blown. Failure of power supply. Poor connection in line cord or rectifier wiring. Poor contact in AC-DC power switch on repeater or 115V-230V switch in power unit. Fuse D blown due to short-circuited electrolytic capacitors C1 or C2. Open wiring in transformers T1 or T2 or in retardation coil L1.
(9) Low d-c output voltage.	Low a-c voltage. 115V-230V switch in power unit may be on 230 AC position when input is 115 volts a-c. Selenium rectifier discs, varistor A in power unit circuit may need replacing. This varistor should be replaced soon after it becomes necessary to set the ADJ VOLTS switch at the maximum INCREASE position to obtain a 115V d-c output with a 115V a-c input.
(10) High d-c output voltage.	High a-c line voltage. 115V-230V switch may be on 115V AC position when input is 230 volts a-c. Resistor R in power unit or other circuits in repeater may be open. (High voltage will appear at light or no-load only.)
(11) Erratic d-c output voltage.	Electrolytic capacitor C1 or C2 may require replacement.

b. Point-to-point Voltages and Resistance Measurements.—Remove equipment from carrying case and remove cover from rectifier power unit. Open resistor panel on rear of equipment to expose terminals of flat-type resis-

tors. Refer to functional schematic circuits, detail schematic circuit figure 38, and wiring diagram figure 39.

CAUTION: Do not touch terminals with hands as high voltages are present. Do not allow one test pick to touch two metal parts at the same time because dangerous short circuits may occur. All values are typical and not absolute. Variations in testing meters, voltages, and resistances may produce results up to ±15 per cent from values shown herein except for resistance of polar relay windings.

Purpose of Test and Preparation	Winding	Resistance Value
(1) To check resistance of windings of Polar Relay D-164816. Remove relays from repeater. Viewing relay from the terminal pin side as shown in figure 7 the terminal pin just to the right of the top center will be terminal 1. The terminals are numbered consecutively from this point in a clockwise direction.	3-6	90 ±9 ohms
	2-7	1450 ±145 ohms
	8-9	1450 ±145 ohms

Check all terminals for ground to relay framework. No terminals should be grounded and each should indicate infinite resistance to the framework.

	Voltage Drop Across	A-c Voltage Measurements
(2) To check voltage drops in rectifier power unit under normal marking load of 300 milliamperes. Connect printer and turn LOCAL switch to position 1. Turn LINE switch to position 1. Connect a 500-ohm resistor externally between LINE 1 binding post and GND binding post and connect GND binding post to ground. Connect power cord to 115V a-c, 50-60-cycle power supply. Adjust voltage to 115 volts and adjust line current to 18 milliamperes.	Midpoint of transformer T1 to common terminal C.	113 volts
	Total winding of transformer T1.	225 volts
	Primary winding of transformer T2.	211 volts
	Secondary winding of transformer T2.	197 volts
	A-c input terminals of varistor A.	148 volts
		D-c Voltage Measurements
	+ and - terminals of varistor A.	116.75 volts

		D-c Voltage Measurements
	Retardation coil L1.	1.75 volts
	+ and - output terminals of rectifier power unit.	115 volts

(3) To check value of series resistors associated with ADJ LINE CURRENT knobs COARSE and FINE.

With COARSE knob in extreme counterclockwise position and FINE knob in maximum increase position meter should read 22 milliamperes.

Turn FINE knob slowly counterclockwise and current should fall smoothly to 16 milliamperes.

Turn COARSE knob one step in INCREASE direction and current should rise to 21 milliamperes.

Turn COARSE knob one more step in INCREASE direction and current should rise to 26.5 milliamperes.

Turn COARSE knob one more step in INCREASE direction and current should rise to 38 milliamperes.

(4) To check retardation coil A and certain resistors with repeater marking and arranged as in paragraph 38b(2).

Voltage Drop Across	D-c Voltage Measurements
Retardation coil A	0.8 volts
Resistor AB	75 volts
Resistor AA	40 volts
Resistor E	75 volts
Resistor M	48 volts
Resistor N	48 volts
Resistor AE	42 volts
Resistor AF	55 volts
Resistor T	107 volts
Resistor P	35 volts
Resistor R	23 volts
Resistor S	38 volts

(5) To check resistors K and Z and varistor A. Repeater arranged as in paragraph 38b(2). Increase

Resistor K (1200-ohm section)	42 volts

minimum current to about 45 milliamperes by turning ADJ LINE CURRENT knobs. This increases the line current so that it overrides the marking bias of the receiving relay and operates it to spacing.

Resistor K (1600-ohm section)	32 volts
Resistor Z	46 volts
Varistor A (Terminal 1 to terminal 3)	9.3 volts

(6) To check resistors H and L. Turn LOCAL switch to position 2. Connect LOCAL 1 binding post to an adjustable resistance box in series with a milliammeter to negative 115V and adjust current to 60 milliamperes. (Note: Line Unit BE-77-A may be used.) Repeater arranged as in paragraph 38b(2) except printer cords removed.

Resistor H	36 volts
Resistor L	30 volts

(7) To check resistors W and J. Turn LOCAL switch to position 5. Connect an adjustable resistance box in series with a milliammeter between LOCAL 1 and LOCAL 2 binding posts and adjust the current to 30 milliamperes. Repeater arranged as in paragraph 38b(2) except printer cords removed.

Resistor W	22 volts
Resistor J	4.5 volts

(8) To check 16-microfarad capacitor E, remove relay R. Connect meter (150-volt scale) to terminals of capacitor. Meter should read about 70 volts. Remove relays S1 and S2 and meter indication gradually falls to zero.

(9) To check spark-killer capacitors and resistors using voltmeter as an ohmmeter. Remove relays R, S1, and S2 and do not have power cord connected.

Resistors X, V, and AD should indicate a resistance of 3200 ohms total (1600 ohms each side of center tap). Resistor AC should indicate 1600 ohms. Capacitors D, F, G, H, K, J, and L should indicate infinite resistance terminal-to-terminal and both terminals to the framework.

(10) The above paragraphs (1) to (9) inclusive pertain to the more important pieces of apparatus used in the equipment and reference should be made to circuit drawing figure 38 and wiring diagram figure 39 for values of apparatus not listed above.

39. REPLACEABLE PARTS.

a. General.—The reference designations shown in the first column of the table in paragraph 39c and d correspond to the designations shown in figure 38 and 39. These designations are also stamped on the equipment or on the mounting panel adjacent to it.

b. List of Manufacturers.

Abbreviation in Par. 39c and Par. 39d	Name	Address
A-B	Allen Bradley Co.	Milwaukee, Wis.
Aerovox	Aerovox Corp.	New Bedford, Mass.
Buss	Bussman Manufacturing Co.	St. Louis, Mo.
Eby	H. H. Eby, Inc.	Philadelphia, Pa.
G-E	General Electric Co., Inc.	Schenectady, N. Y.
H & H	Arrow-Hart & Hegeman Electric Co.	Hartford, Conn.
Hubbell	Harvey Hubbell, Inc.	Bridgeport, Conn.
Jones	H. B. Jones Co.	Chicago, Ill.
K-K	Kurz-Kasch, Inc.	Dayton, Ohio
Littel	Littelfuse, Inc.	Chicago, Ill.
Mal	P. R. Mallory & Co., Inc.	Indianapolis, Ind.
Ohmite	Ohmite Manufacturing Co.	Chicago, Ill.
Pwr Eq	Power Equipment Co.	Detroit, Mich.
Simplex	Simplex Wire & Cable Co.	Boston, Mass.
Solar	Solar Manufacturing Corp.	Bayonne, N. J.
W. E. Co.	Western Electric Co.	New York, N. Y.

c. Table of Replaceable Parts, Repeater Unit

Reference Designation	Stock No.	Name and Description	Function	Manufacturer	Manufacturer's Part No.
	4A2830.1	REPEATER TG-30 (Terminal) is a d-c telegraph terminal repeater. It can be operated from 95-125v or 190-250v, 50-60 cycle a-c power or from 115v externally regulated d-c power. The equipment comprises a repeater unit and a rectifier power unit assembled on shock absorbing supports, in a carrying case 2'-0-3/4" x 1'-2-1/2" x 1'-4" high, which encloses and protects the equipment while in transit.	For use in transmitting to or receiving from another Repeater TG-30 (Terminal) or its equivalent at a distant terminal on a half-duplex basis, either with or without a Repeater TG-31 (Intermediate) at an intermediate point. It is designed for use with printer circuits over field wire and open wire facilities. The line side of the repeater is arranged to employ either the polarential form of transmission or 2-path polar transmission. The local side of the repeater is arranged for operation with a printer or 30 or 60 milliampere neutral (open and close) local circuits or a manual telegraph set integral with the equipment.	W. E. Co.	X-61865
GND	3Z286	BINDING POST: Molded rubber cap 5/8" diameter x 3/8" high, stem 8-32 1/2" long, slot 1/8" x 5/32", bottom of base knurled to prevent turning. Same as LINE 1, LINE 2, LOCAL 1, LOCAL 2, LOCAL 3.	Ground connection	Eby	14RC
LINE 1 LINE 2	3Z286	BINDING POST: Same as GND.	To provide line connections	Eby	14RC
LOCAL 1 LOCAL 2 LOCAL 3	3Z286	BINDING POST: Same as GND.	To provide local connections	Eby	14RC
A B C	3DB20-14	CAPACITOR, FIXED, PAPER: 20μf maximum, 16μf minimum 400 w-v d-c at -40F to +185F ambient temperature, oil filled, 5-19/32" x 4-15/16" x 1-1/2" over-all, rectangular metal can, 4 mounting studs on 4" x 3/4" centers, 2 screw type terminals. Same as E.	Wave-shaping capacitors	W. E. Co.	D-166602
D	3DB1.136A	CAPACITOR, FIXED, PAPER: 1.725μf maximum to 1.275μf minimum, 250 w-v d-c at +32F to +150F, 1" x 1-1/2" x 3-1/2" rectangular metal case, hermetically sealed, 15/16" rubber insulated terminals, wax filled, two mounting studs. (Moisture resistant W.E.Co. 229A.)	Spark killer for spacing contact of relay R.	W. E. Co.	D-163136A
E	3DB20-14	CAPACITOR: Same as A.	Part of antikick-off network for relay R.	W. E. Co.	D-166602
F	3DA400-3	CAPACITOR, FIXED, PAPER: 0.4μf ±15%, 250 w-v d-c at +32F to +150F ambient temperature. 3-9/16" x 1-1/2" x 37/64" over-all, rectangular metal case, hermetically sealed, rubber insulated terminals, single mounting stud and terminals on same end of case. (Moisture resistant W.E.Co. 230A.)	Spark killer for marking contact of relay R.	W. E. Co.	D-162242A 0.4μf

Reference Designation	Stock No.	Name and Description	Function	Manufacturer	Manufacturer's Part No.
G	3DB50-8	CAPACITOR, FIXED, PAPER: 0.50 μf ±10%, 400 w-v d-c at -40F to +185F ambient temperature 3-1/2" high x 1" x 1-1/2" rectangular metal case, hermetically sealed, rubber insulated terminals extend 15/16" above top, oil filled, two mounting studs on 1" centers and terminals on same end of case. Same as H, J, K, and L.	Spark killer for marking contact of relay L1.	W. E. Co.	D-161655
H	3DB50-8	CAPACITOR: Same as G.	Spark killer for spacing contact of relay S1.	W. E. Co.	D-161555
J	3DB50-8	CAPACITOR: Same as G.	Spark killer for marking contact of relay S2.	W. E. Co.	D-161555
K	3DB50-8	CAPACITOR: Same as G.	Spark killer for spacing contact of relay S2.	W. E. Co.	D-161555
L	3DB50-8	CAPACITOR: Same as G.	Printer sending contacts spark killer.	W. E. Co.	D-161555
M	3DA1-101	CAPACITOR, FIXED, PAPER: .001 μf -10% to +20%, 1600 w-v d-c at -40F to 185F ambient temperature 11/16" diameter 1-5/16" long, tubular, 2-1/2" axial lead at each end, mineral oil impregnated, in tinned brass tube, mounting strap attached, moisture resistant.	Part of manual telegraph set oscillator circuit.	Solar	XTIMW-16-.001
		or			
	3DA1-107	FIXED PAPER: .001 μf -10% to +20%, 2000 w-v d-c up to 65C. 13/16" diameter, 2-3/16" long. Axial wire lead 2-1/2" long at each end. Equipped with center mounting strap, having a flat projection with two 5/32" diameter holes. Moisture resistant.		Aerovox	2089,.001 μf
N	3DA10-158	CAPACITOR, FIXED, PAPER: 10,000 μf ±20%, 400 w-v d-c, ambient temperature -40F to +185F 13/16" x 13/16" x 19/64" molded with 1-5/16" terminals at each end. Mineral oil impregnated.	Spark killer for telegraph key.	W. E. Co.	404C
P	3DEB5.75	CAPACITOR, FIXED: 5 μf ±15%, 250 w-v d-c at +32F to +150F. 4-23/32" x 1-15/32" x 2-13/32" rectangular, hermetically sealed, tin plate case housing four high temperature paper capacitor units connected in parallel, two 11/32" terminals, two mounting studs on 7/8" centers.	Wave shaper for receiving magnet of printer.	W. E. Co.	D-163138
-	4E400	CONNECTING BLOCK: 1-15/16" x 1-15/16" x 1/2" over-all exclusive of terminals, 9-prong vacuum tube socket made of molded insulating material and mounted in square metal frame, fits relay D-164816.	Holds relays R, S1, and S2 and provides connections to repeater circuit.	W. E. Co.	D-164882
(Spare)	4E400		To hold a spare relay.	W. E. Co.	D-164882
-	3Z4035-14	CORD: 4'-0" long, 2-conductor, tinsel, rubber covered, glazed cotton braid on each conductor, both conductors covered by cotton braid. Equipped with a 47 plug at one end, the other end has free conductors 2" long equipped with no. 129 cord tips.	Headset cord.	W. E. Co.	D-161768

Reference Designation	Stock No.	Name and Description	Function	Manufacturer	Manufacturer's Part No.
-	3E7145	CORD: 10'-0" long, 18 AWG, two stranded rubber covered conductors with outer rubber jacket.	Power cord for connecting to power supply.	Simplex	SJ, 2 cond., 18 AWG
A, B, C, D	3Z1892-5.1	FILTER: Two paper and aluminum foil capacitor units, two paper filled retardation coils with a common core of permalloy laminations, mounted in 3-1/2" x 1-1/2" x 1" rectangular metal case, terminals project 7/8" from top and bottom, equipped with two mounting studs, wax filled, hermetically sealed, moisture resistant.	To prevent radio frequencies generated within the set from causing interference to nearby radio receiving equipment over local connections to other equipment.	W. E. Co.	D-163039
E, F	3Z1892-1.3	FILTER: Two retardation coils and one capacitor assembled on a mounting bracket. Approximate over-all dimensions; 3-3/16" x 2-3/16" x 1-5/16", including bracket and terminals. Moisture resistant.	To prevent radio frequencies generated within the set from causing interference to nearby radio receiving equipment over local connections to power supply.	W. E. Co.	D-162943
A, B	3Z2595.6	FUSE: 1/2 ampere 250v, 1/4" x 1" glass tube with fuse enclosed, nickel plated caps.	A fuses positive and B negative leads to repeater circuit.	Buss	8AG 1/2
C	3Z2605.8	FUSE: 5 amperes slow blow, 25v, 9/32" x 1-1/4" enclosed in glass tube with nickel plated caps, combination thermal element and fuse.	Main power supply	Buss	MDM5
-	3Z3285-3	FUSE EXTRACTOR POST: Cylindrical, molded black bakelite, 2" long exclusive of 3/8" long terminal at end, second terminal at sides, fits 5/8" mounting hole, finger operated knob 5/8" diameter.	For main power supply and power unit.	Buss	HCM
-	3Z3285-6	FUSE EXTRACTOR POST: Cylindrical, molded black bakelite, 7/16" diameter x 2" with 3/8" terminal at end, second terminal at side, finger operated knob 11/16" diameter, mounts in 1/2" hole.	For fuses A and B.	Buss	HJM
-	2B740	HEADBAND: Wire headband with pad, 6" diameter x 2-3/32" at widest part. Used with Nos. 128, 157, 525 or 528 receivers.	For use with headset receiver.	W. E. Co.	D-142091
HEADSET	4C4715A.1	JACK, SWITCHBOARD TYPE: Tip, sleeve, extra set of make contacts, 9/16" x 13/16" x 3-13/32" over-all. Mounts in 29/64" drilling, heavily insulated, singly mounted, single mounting lug. Used with 47 type plugs. (W. E. Co. 215A)	For connecting cord and plug attached to receiver of manual telegraph set.	W. E. Co.	D-161891-215

Reference Designation	Stock No.	Name and Description	Function	Manufacturer	Manufacturer's Part No.
R RED	2Z5524	JACK, SWITCHBOARD: Tip, sleeve, and one contact connected to tip which breaks when plug is in jack. 9/16" x 13/16" x 3-13/32" over-all, heavily insulated, singly mounted, one mounting lug. (W.E.Co. 218A)	For connecting receive cord of printer	W. E. Co.	D-161891-218A
S BLK	2Z5524	JACK: Same as R RED.	For connecting send cord of printer	W. E. Co.	D-161891-218A
TEST SET	4C4885C.1	JACK, SWITCHBOARD: Tip, ring, sleeve, and two sets of make contacts, 9/16" x 13/16" x 3-23/64", heavily insulated, singly mounted, one mounting lug.	For connecting polar relay test set.	W. E. Co.	D-163718-285
-	4Z5174	JACK MOUNTING: 2-1/8" x 1" x 17/32" thick masonite die stock arranged for mounting two jacks.	For send and rec printer jacks.	W. E. Co.	P-264485
-	4Z5175	JACK MOUNTING: Masonite die stock 2-3/8" x 1-1/2" x 17/32" thick. Arranged for mounting three jacks.	For headset jack, test jack and MEAS VOLTS key.	W. E. Co.	P-264486
MEAS VOLTS	4C5105.47B1	KEY: Nonlocking, push button, two sets of transfer contacts, 3-41/64" long, mounts in jack drillings 29/66" diameter black button. (W.E.Co. 547B)	Establishes connections to enable using the milliammeter as a voltmeter.	W. E. Co.	D-161894
TELEG KEY	3Z3602-4	KEY: A legless telegraph key mounted on a hard rubber base equipped with four binding posts. Provided with a set of front and back contacts and circuit closing switch. 5-29/32" x 3-1/2" x 1-3/4" over-all dimensions. (W.E.Co. 2A pole changer.)	Telegraph key used with manual telegraph set.	W. E. Co.	D-165581
TONE	2Z5888	LAMP, NEON: 1/10 watt. May be used at any voltage above 90v d-c or 65v a-c provided series resistance is used to limit current to 1 milliampere. Recommended 100,000 for 110v, 200,000 for 220v, etc., 1 3/4" x 9/32" neon lamp with octagonal base.	Manual telegraph set oscillator	Littel	5122
-	2Z5984.2	LAMP MOUNTING: Cylindrical, black bakelite body, transparent molded cap, 2-7/8" long, fits 1/2" diameter hole.	For neon lamp TONE	Littel	1414

Reference Designation	Stock No.	Name and Description	Function	Manufacturer	Manufacturer's Part No.
NA	3F905-17	MILLIAMMETER: Scale 50-0-50. 3-1/2" flush type. Bakelite case, self-contained, moving coil permanent magnet type, 50 scale divisions, red lines on right side of zero marked .018 AMP and 115V. Current for end scale deflection 5 milliamperes d-c. Approximately 5Ω. Accuracy ±2% of full scale. Calibrated for use on .09" thick steel plate.	Measures line current and input voltage to repeater circuit.	W. E. Co.	D-164547
	6Z1735	PLUG CAP: Parallel blade, rubber, cord grip, attachment plug cap. Cord diameter 0.296" to 0.562", 10 amperes 250v, 15 amperes, 125v.	Power cord	Hubbell	9754
ADJ TONE	2Z7273-2	POTENTIOMETER: Adjustable, 1 megohm ±2%, linear taper, 2 watts. 1-1/16" diameter x 9/16" thick, three 5/16" terminals, carbon composition, metal case, 3/8" diameter, shaft 1/4" diameter x 7/8" long, corrosion resistant.	Adjusts tone heard in receiver used in Manual Telegraph Set.	A-B	J-U 1052-CR
ADJ LINE CURRENT	2Z7279-20	POTENTIOMETER: 1250Ω, 50 watts, adjustable 2-5/16" diameter x 1-3/8" thick, round vitreous enamel, wire wound, ceramic body, three 9/16" terminals, 1/4" diameter shaft projecting 7/8" in front of body.	FINE adjustment for line current.	W. E. Co.	KS-8852 L6
LINE 1	4E926	PROTECTOR BLOCK: 1-1/4" x 3/8" x 5/32" thick block of hard carbon, which with 27 block forms open space cutout without the use of separator.	To protect equipment against line voltage surges	W. E. Co.	26
LINE 2	4E927	PROTECTOR BLOCK: 1-1/4" x 3/8" x 5/16" thick grooved porcelain frame block, provided with a carbon insert depressed below the surface of the porcelain and held in place by means of fusable cement. With 26 block forms open space cutout without use of separator.	To protect equipment against line voltage surges.	W. E. Co.	27
	2B2109	RECEIVER: Watchcase type, resistance approximately 1100Ω. Nickel plated metal case and hard rubber cap diameter 2-27/64", depth 1-11/64".	For listening to manual telegraph signals.	W. E. Co.	509
PRINTER POWER		RECEPTACLE: Female flush motor plug, T slots 10 amperes 250v 15 amperes 125v. Diameter 1.593" depth 1.281" oval plate with two 0.203" holes 2.062" apart.	For connecting printer motor power cord.	Hubbell	7332

Reference Designation	Stock No.	Name and Description	Function	Manufacturer	Manufacturer's Part No.
R	4C9156	RELAY: Polarized, nine terminals, three windings, jack mounted on D-164882 connecting block. 99ω maximum, 81ω minimum, primary winding, terminals 3 and 6. 1595ω maximum, 1305ω minimum, secondary winding, terminals 2 and 7, 1595ω maximum, 1305ω minimum, tertiary winding, terminals 8 and 9. 1-5/16" x 1-5/16" x 5-1/16" over-all, square base, rectangular phenol fibre cover held in place by thumb screw, cover sprayed with copper for shielding and given outer grey enamel finish; permalloy reed type armature, antichatter contacts, hexagonal pole-piece adjusting nuts. Moisture resistant. Same as S1 and S2.	For receiving incoming signals	W. E. Co.	D-164816
SPARE	4C9156		To serve as a spare relay for R, S1, or S2.	W. E. Co.	D-164816
S1	4C9156	RELAY: Same as R.	For transmitting printer and manual telegraph signals.	W. E. Co.	D-164816
S2	4C9156	RELAY: Same as R.	Transmitting relay when LINE switch is in position 1 or 3 and holding relay for R relay when the LINE switch is in position 2.	W. E. Co.	D-164816
A	3Z6089	RESISTOR: Fixed, 209ω ±1% 2 watts, 890ω ±1%, 5 watts, total both windings 5 watts, flat type. 1-1/2" x 13/64" x 4-21/32" over-all mounting studs on 1-5/16" centers, three terminals, two windings, wire wound on core of heat resisting material. (Moisture resistant W.E.Co. 19MP.) Same as C.	209ω section serves for wave shaping. 890ω section is part of COARSE line current adjustment.	W. E. Co.	D-161700MP
B	3Z6080-28	RESISTOR: Fixed, 800ω ±1%, 5 watts, flat type. 13/64" x 1-1/2" x 4-21/32" over-all mounting studs on 1-5/16" centers, wire wound on core of heat resisting material. (Moisture resistant W.E.Co. 18GF) Same as AF.	Part of COARSE current adjustment	W. E. Co.	D-161699GF
C	3Z6089	RESISTOR: Same as A.	Part of COARSE current adjustment.	W. E. Co.	D-161700MP
D	3Z6090-5	RESISTOR: Same as A except fixed resistance 100ω ±1%, 1 watt and 900ω ±1%, 5 watts, total both windings 5 watts. (Moisture resistant W.E.Co. 19UD)	Series and shunt resistance for meter.	W. E. Co.	D-161700UD
E	3Z6160-5	RESISTOR: Same as A except fixed resistance 1200ω ±1% and 1600ω ±1%, 5 watts either or both windings. (Moisture resistant W.E.Co. 19PS.) Same as K.	Spacing load for rectifier	W. E. Co.	D-161700PS

Reference Designation	Stock No.	Name and Description	Function	Manufacturer	Manufacturer's Part No.
F	3Z6615A3	RESISTOR: Fixed, 15,350ω ±1%, 1 watt. 1-1/2" x 1/2" diameter phenol fibre outer tube with 2" axial lead at each end. Wire wound on bakelite core. (Moisture resistant. W.E.Co. 107A.) Same as G.	Current limiter for milliammeter when serving as a voltmeter.	W. E. Co.	D-164888A 15,350ω
G	3Z6615A3	RESISTOR: Same as F.	Current limiter for milliammeter when serving as a voltmeter.	W. E. Co.	D-164888A 15,350ω
H	3Z6080-22	RESISTOR: Same as A except fixed resistance 400ω ±1% and 800ω ±1%, 5 watts either or both windings. (Moisture resistant W.E.Co. 19NT.)	S1 and S2 relay shunt (line windings).	W. E. Co.	D-161700NT
J	3Z6060-38	RESISTOR: Same as A except fixed resistance 200ω ±5%, 3 watts, 600ω ±5%, 5 watts total both windings 5 watts. (Moisture resistant W.E.Co. 19PY.)	Current limiter for bias windings of relays S1 and S2. Same as P, R and S.	W. E. Co.	D-161700PY
K	3Z6160-5	RESISTOR: Same as E.	Part of antikick-off circuit.	W. E. Co.	D-161700PS
L	3Z6100-89	RESISTOR: Same as B except fixed resistance 1000ω ±1%, 5 watts. (Moisture resistant W.E.Co. 18BM.) Same as Y.	Local circuit current limiter	W. E. Co.	D-161699BM
M	3Z6250-36	RESISTOR: Same as A except fixed resistance 2500ω ±1%, 5 watts each winding, total both windings 5 watts. (Moisture resistant W.E.Co. 19UA.) Same as N.	Current limiter for bias winding of relay R.	W. E. Co.	D-161700UA
N	3Z6250-36	RESISTOR: Same as M.	Current limiter for bias winding of relay R.	W. E. Co.	D-161700UA
P	3Z6507-1	RESISTOR: Same as A except fixed resistance 510ω ±1%, 1 watt, 5700ω ±1% 5 watts, total both windings 5 watts. (Moisture resistant W.E.Co. 19RT.)	Current limiter for bias windings of relays S1 and S2. Same as J, R and S.	W. E. Co.	D-161700RT
R	3Z6246	RESISTOR: Same as A except fixed resistance 1670ω ±1% 5 watts and 2460ω ±1% 5 watts, total both windings 5 watts. (Moisture resistant W.E.Co. 19SD.)	Current limiter for bias windings of relays S1 and S2. Same as J, P and S.	W. E. Co.	D-161700SD
S	3Z6502	RESISTOR: Same as A except fixed resistance 1705ω ±1%, 3 watts, 5200ω ±1%, 5 watts. Maximum both windings 5 watts. (Moisture resistant W.E.Co. 19TJ.)	Current limiter for bias windings of relays S1 and S2. Same as J, P and R.	W. E. Co.	D-161700TJ

Reference Designation	Stock No.	Name and Description	Function	Manufacturer	Manufacturer's Part No.
T	3Z6350-9	RESISTOR: Same as A except fixed resistance 102.6ω ±1/2%, 1 watt and 3509ω ±1/2%, 5 watts, maximum both windings 5 watts. (Moisture resistant W.E.Co. 19PC.)	Current limiter for line windings of relays S1 and S2.	W. E. Co.	D-161700PC
V	3Z6160-4	RESISTOR: Same as A except fixed resistance 1600ω ±5%, 1600ω ±5%, 5 watts, either winding or both. (Moisture resistant W.E.Co. 19JE.) Same as X, AD.	Spark killer resistor for relay S1.	W. E. Co.	D-161700JE
W	3Z6036B2	RESISTOR: Same as A except fixed resistance 362ω ±1% each winding, 5 watts. Either or both windings. (Moisture resistant W.E.Co. 19MB.)	Current limiter for line windings of relays S1 and S2.	W. E. Co.	D-161700MB
X	3Z6160-4	RESISTOR: Same as V.	Spark killer for relay R.	W. E. Co.	D-161700JE
Y	3Z6100-89	RESISTOR: Same as L.	Part of antikick-off circuit when LINE switch is in position 2.	W. E. Co.	D-161699BM
Z	3Z6200-49	RESISTOR: Same as B except fixed resistance 2000ω ±1%, 5 watts. (Moisture resistant W.E.Co. 18CR.)	Current limiter for holding windings of relays S1 and S2.	W. E. Co.	D-161699CR
AA	3Z6022-17	RESISTOR: Fixed, 220ω ±2%, 25 watts. 25/32" diameter x 2" long, tubular, wire wound, vitreous enameled, 5/8" radial terminal near each end.	Part of transmitting branch potentiometer.	W. E. Co.	D-164781
AB	3Z6055	RESISTOR: Fixed, 550ω ±2%, 25 watts. 25/32" diameter x 2" long, tubular, wire wound, vitreous enameled, 5/8" radial terminal near each end.	Part of transmitting branch potentiometer.	W. E. Co.	D-164782
AC	3Z6160-7	RESISTOR: Same as B except fixed resistance 1600ω ±5%, 5 watts. (Moisture resistant W.E.Co. 18AT.)	Printer sending contacts spark killer.	W. E. Co.	D-161699AT
AD	3Z6160-4	RESISTOR: Same as V.	Spark killer for relay S2.	W. E. Co.	D-161700JE
AE	3Z6060-24	RESISTOR: Same as B except fixed resistance 600ω ±1%, 5 watts. (Moisture resistant W.E.Co. 18GH.)	Current limiter for receiving magnet.	W. E. Co.	D-161699GH
AF	3Z6080-28	RESISTOR: Same as B.	Current limiter for receiving magnet.	W. E. Co.	D-161699GF

Reference Designation	Stock No.	Name and Description	Function	Manufacturer	Manufacturer's Part No.
AG	3Z6801-16	RESISTOR: 1 megohm ±20%, 1/2 watt. 5/8" x 3/16" diameter molded in phenol plastic compound in cylindrical form, 1-1/2" axial lead at each end, metallized glass tube filement resistance element.	Part of manual telegraph set oscillator circuit.	W. E. Co.	KS-8050D 1 megohm
A	3G1987-18L	RETARDATION COIL: Inductance 2 henries at 25 cps. Single winding, approximately d-c resistance 45Ω. 1-3/16" x 1-11/16" x 4-1/4" over-all. Rectangular metal case, closed core coils, electromagnetic shield, stud mounted. (Moisture resistant W.E.Co. 307L.)	Telephone noise killer.	W. E. Co.	D-161818L
ADJ LINE CURRENT	3Z9825-66.16	SWITCH: Single section rotary selection, two circuits of four positions each, 2-1/16" diameter x 1-23/32" deep over-all. Contact terminals and rotor segments are silver plated. Arranged for operation by knob.	Provides COARSE adjustments for line current.	W. E. Co.	KS-9059
LINE	3Z9825-66.15	SWITCH: Four section rotary selector. Three circuits in each of four sections, 2-1/16" diameter x 2-31/32" deep over-all. Arranged for operation by knob. Each circuit has three silver plated nonshorting contacts.	Provides line options.	W. E. Co.	KS-9060
LOCAL	3Z9825-66.14	SWITCH: Four section rotary selector switch. Two circuits in each section. 2-1/16" diameter x 3-15/32" deep over-all. Each circuit has five silver plated nonshorting type contacts. Arranged for operation by knob.	Provides local options.	W. E. Co.	KS-9061
115V D-C	3Z9903A-3	SWITCH ASSEMBLY: 4-1/8" x 1-1/2" x 1/32" steel detail on which are mounted three Hubbell 1313 3-way toggle flush switches.	A-c, d-c switch. In a-c position when source of power is a-c and in d-c position when source of power is d-c.	Hubbell	BL-11334
A	2Z9405.3	TERMINAL STRIP: 7/8" x 13/32" x 1-1/2", two terminals, two 5-40 x 3/16" nickel plated brass screws per terminal connected by nickel plated brass strip, mounted in bakelite base with bakelite barriers between terminals, terminals on 3/8" centers, strip is screw mounted.	For connecting power cord to repeater.	Jones	2-140
A	3H4956-20	VARISTOR: Blocking valve rectifier. Twenty selenium discs approximately 1-3/8" diameter assembled on stud supported by two mounting brackets, discs are in two stacks, one of five and the other fifteen discs. 1-3/8" x 2-1/8" x 4-1/2" over-all, four screw holes in mounting bracket on 25/32" x 4" centers.	Part of antikick circuit for relay R.	W. E. Co.	KS-9020

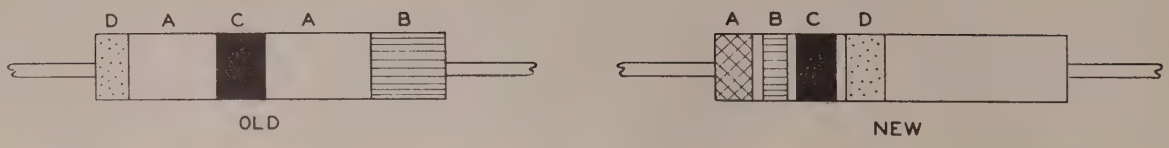
Reference Designation	Stock No.	Name and Description	Function	Manufacturer	Manufacturer's Part No.
	3Z13000	YOKE: 2-1/2" x 1" x 1/32" approximately. Metal detail. Bent to fit over the handles of toggle switches used in assembly BL-11334.	To operate three switches in tandem	Hubbell	BL-11251

d. Table of Replaceable Parts, Rectifier Power Unit

Reference Designation	Stock No.	Name and Description	Function	Manufacturer	Manufacturer's Part No.
-	3H4956-22	POWER UNIT: 115v, 0.4 ampere rectifier.	Changes 115v a-c into 115v d-c	W. E. Co.	KS-5825 List 01
-	3Z930	CAP: Consists of molded phenol material, cylindrical in shape, with metal insert for making contact with a fuse and provided with bayonet type fastener. The insert is also arranged to hold fuse when cap is removed from fuse holder. Face is engraved with arrow and FUSE. Used with HKM fuse holder for 3AG type fuses.	Part of Bussman fuse mounting	Buss	9363 1/2
C1 C2	3DB500-7	CAPACITOR: 500μf -10% +75%, 200v d-c, 2-1/16" x 4-3/8", cylindrical, circular bracket, bakelite, solder lugs.	Load filter	Mal	MD-C36
L1	3C1700	COIL: D-c resistance of winding 4.93Ω at 24C effective inductance with 139v 60 cps applied to winding 5.4 henries with .06 ampere d-c in winding and 1.2 henries with 0.4 ampere d-c in winding. 3-3/4" x 3-1/8" x 4-1/2" exclusive of terminals, shell type coil, steel half shell on rear, silicon steel core, four 10-24 studs 3/8" long on 2-1/2 x 3-1/8 centers for mounting through 2-1/4 x 2-9/16 cutout in 1/8" steel plate, nuts furnished, solder terminals on front of coil.	Ripple suppression	Pwr Eq	RF-62
D	3Z1926	FUSE: 1.0 ampere 250v. 1/4" x 1-1/4" glass tube with fuse enclosed, nickel plated caps.	Overcurrent protection	Buss Littel	3AG-1 1040
	2Z5822-2	KNOB: Bar knob with pointer, black insulating material with white line on pointer, radius 3/4", height 7/8".	Used with switch 212-6	K-K	S-246-3L
	3Z3285-2	MOUNTING: Approximately 7/16" x 2" with 3/8" terminal at end, second terminal at side held mechanically and soldered, cylindrical, molded black bakelite, finger operated knob 11/16" diameter mounts in 1/2" hole in panel, threads on body with nut and neoprene washer for mounting. Can be locked in panel; cap can be removed by turning 1/4 revolution.	Holds fuse	Buss	HKM
	3Z3275-1	MOUNTING: Same as HKM except: (1) cap requires three revolutions for removal, (2) the terminal at side is held by solder only, (3) it can not be locked in panel and (4) it projects less in front of panel and more behind the panel.	Holds fuse	Littel	1075A

Reference Designation	Stock No.	Name and Description	Function	Manufacturer	Manufacturer's Part No.
R	3Z6400-31	RESISTOR: 4000$^{\omega}$ ±10%, 316v maximum .079 ampere maximum 25 watts. Core 2" x 9/16", wire wound, vitreous enameled, tubular ceramic core, radial terminals near each end, radial supporting lugs at each end.	Voltage stabilizer at light load	Ohmite	0211
-	3Z8300-4	SWITCH: Six taps, rotary motion 150 degrees, 15 amperes, 150v. 2-1/4" diameter x 1-7/16" thick with 1/4" diameter x 7/8" long shaft, maximum 1/4" panel, 3/8"-32 threaded bushing and hexagonal nut for mounting.	Adjusts output voltage	Ohmite	212-6
-	3Z9846.2	SWITCH: S.P.D.T. 3 amperes 125v. Toggle switch, 15/32" diameter x 3/8" long mounting bushing, 5/8" wide x 1-9/16" long x 1/2" deep, laminated bakelite body, soldering lugs on ends.	A-c line	H & H	21350
T1	2Z9621-5	TRANSFORMER: Auto type. Single 250v winding with taps at 125v, 227v, 232v, 241v, and 245v. These may be measured with 125v or 250v 50-60 cps on either the 125 or 250 tap respectively. Entire winding from common (or start) 227 through 250 used to deliver up to 0.8 ampere to primary of rectifier transformer T99 and 1.25 amperes to inductive motor load across common and 115v tap. Both loads may be applied simultaneously. 3-3/4" x 3-1/8" x 4-1/2" exclusive of terminals, shell type coil, steel half shell on rear, silicon steel core, four 10-24 studs 3/8" long on 2-1/2 x 3-1/8 centers for mounting in 1/8" steel plate, nuts furnished, solder terminals on front of coil.	Changes 230v a-c input to 115v for external motor	Pwr Eq	T98
T2	2Z9615.6	TRANSFORMER: Two-winding type, primary 250v 50-60 cps, electrostatic shield between primary, and secondary. Secondary is 250v total with taps at 150v, 170v, 190v, 210v, and 230v. With 250v 50-60 cps applied to primary, secondary will deliver 0.5 ampere maximum from common and any tap at rated voltage into selenium varistor with choke input filter. Combination rated to deliver 0.4 ampere d-c. 3-3/4" x 3-1/8" x 4-1/2" exclusive of terminals, shell type coil, four 10-24 studs 3/8" long on 2-1/2 x 3-1/8 centers for mounting in 1/8" steel plate, nuts furnished, solder terminals on front of coil.	Changes input voltage to voltage required by rectifier	Pwr Eq	T99
A	3H4956-21	VARISTOR: Full-wave rectifier 216v 25-60 cps 35C maximum ambient temperature. Output 0.2 ampere d-c at 72v. Consists of four 1-1/2" x 5" long units each comprising twelve selenium rectifier discs approximately 1-1/2" diameter. Each unit assembled on a stud.	Rectification	G-E	4-6RS5E4 connected 4-12-1

d. RMA Standard Color Code for Resistors in Ohms and Capacitors in Micromicrofarads.



A - Color for 1st significant figure.
B - Color for 2nd significant figure.
C - Color for number of ciphers or multiplier.
D - Gold or silver indicates tolerance, when applied.

COLOR	SIGNIFICANT FIGURE	MULTIPLYING VALUE
Black	0	1
Brown	1	10
Red	2	100
Orange	3	1000
Yellow	4	10,000
Green	5	100,000
Blue	6	1,000,000
Violet	7	10,000,000
Gray	8	100,000,000
White	9	1,000,000,000
Gold	±5% tolerance	0.1
Silver	±10% tolerance	0.01
No color	±20% tolerance	-

EXAMPLES

43,000 ohms	Yellow (4)	Orange (3)	Orange (X1000)
3000 ohms	Orange (3)	Black (0)	Red (X100)
3.3 ohms	Orange (3)	Orange (3)	Gold (0.1)

[A. G. 300.7 (19 Oct. 1943).]

By Order of the Secretary of War:

G. C. MARSHALL,
Chief of Staff

Official:

J. A. ULIO,
Major General,
The Adjutant General

Distribution: IC 11(5)

(For explanation of symbols, see FM 21-6)

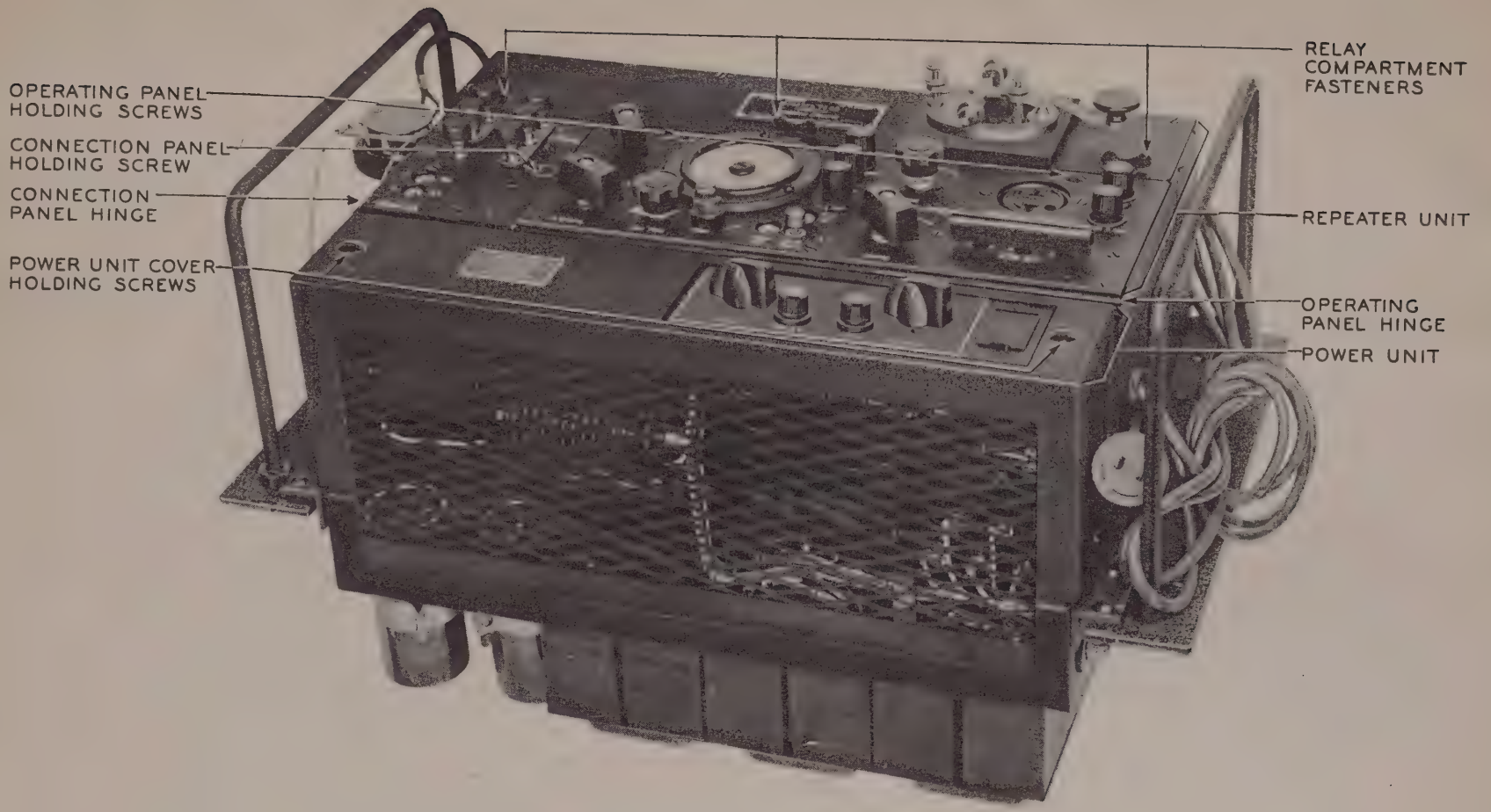


Figure 32 - Repeater TG-30 (Terminal), Removed from Carrying Case, Front View

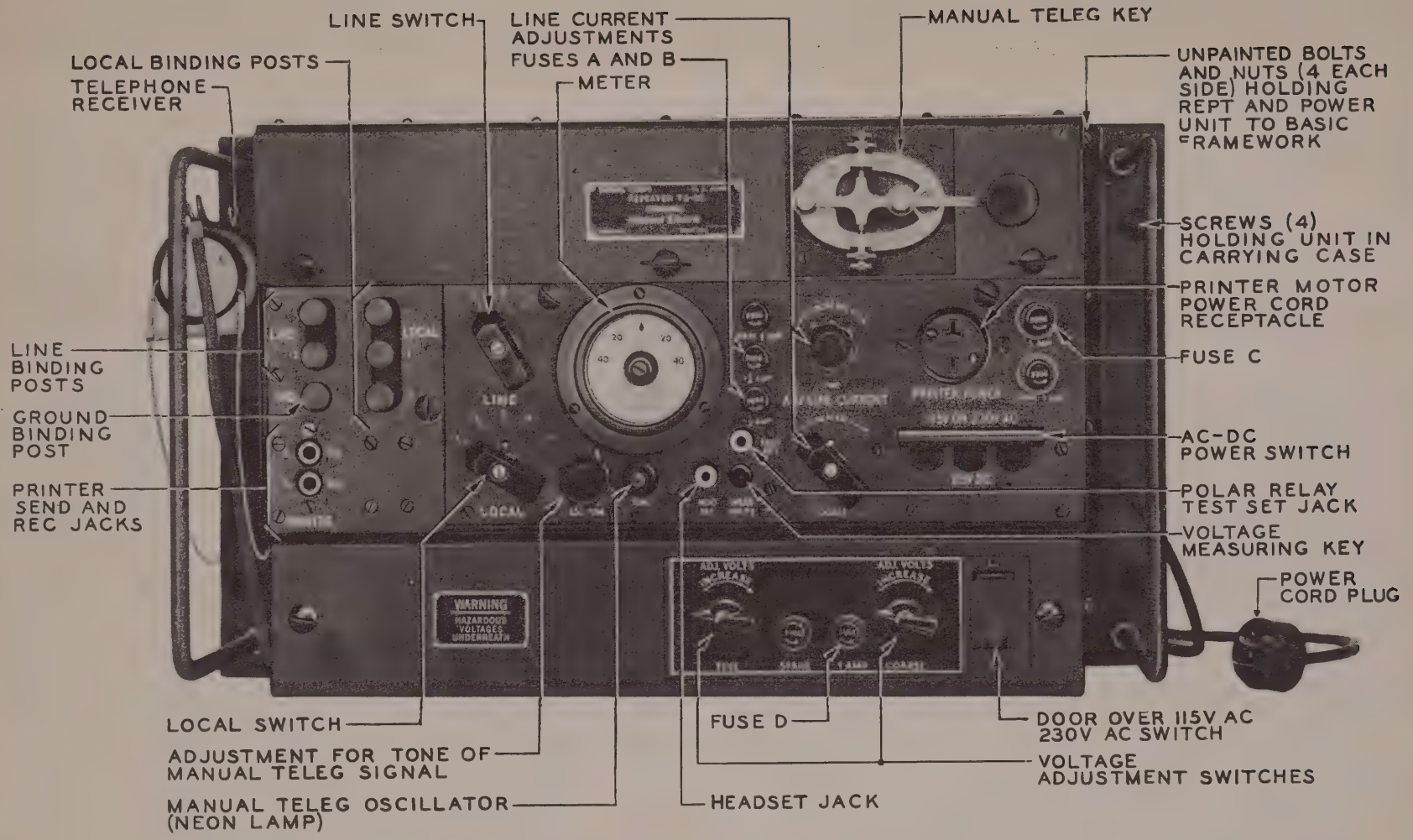

LINE SWITCH
LINE CURRENT ADJUSTMENTS
FUSES A AND B
METER
MANUAL TELEG KEY
LOCAL BINDING POSTS
TELEPHONE RECEIVER
UNPAINTED BOLTS AND NUTS (4 EACH SIDE) HOLDING REPT AND POWER UNIT TO BASIC FRAMEWORK
SCREWS (4) HOLDING UNIT IN CARRYING CASE
PRINTER MOTOR POWER CORD RECEPTACLE
FUSE C
LINE BINDING POSTS
GROUND BINDING POST
AC-DC POWER SWITCH
PRINTER SEND AND REC JACKS
POLAR RELAY TEST SET JACK
VOLTAGE MEASURING KEY
POWER CORD PLUG
LOCAL SWITCH
ADJUSTMENT FOR TONE OF MANUAL TELEG SIGNAL
MANUAL TELEG OSCILLATOR (NEON LAMP)
FUSE D
HEADSET JACK
DOOR OVER 115V AC 230V AC SWITCH
VOLTAGE ADJUSTMENT SWITCHES

Figure 33 - Repeater TG-30 (Terminal), Removed from Carrying Case, Top View

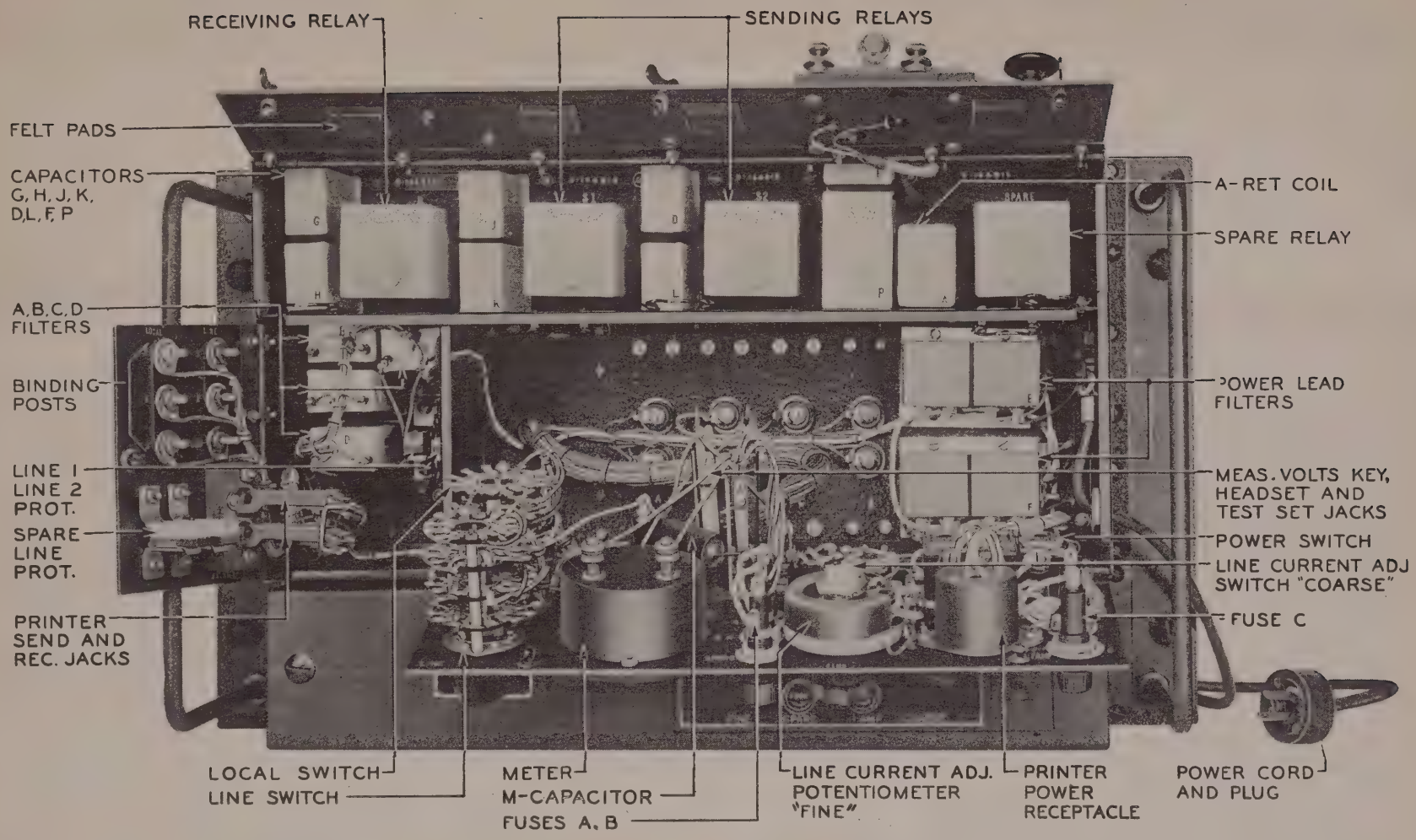


Figure 34 - Repeater TG-30 (Terminal), Top Panels Open

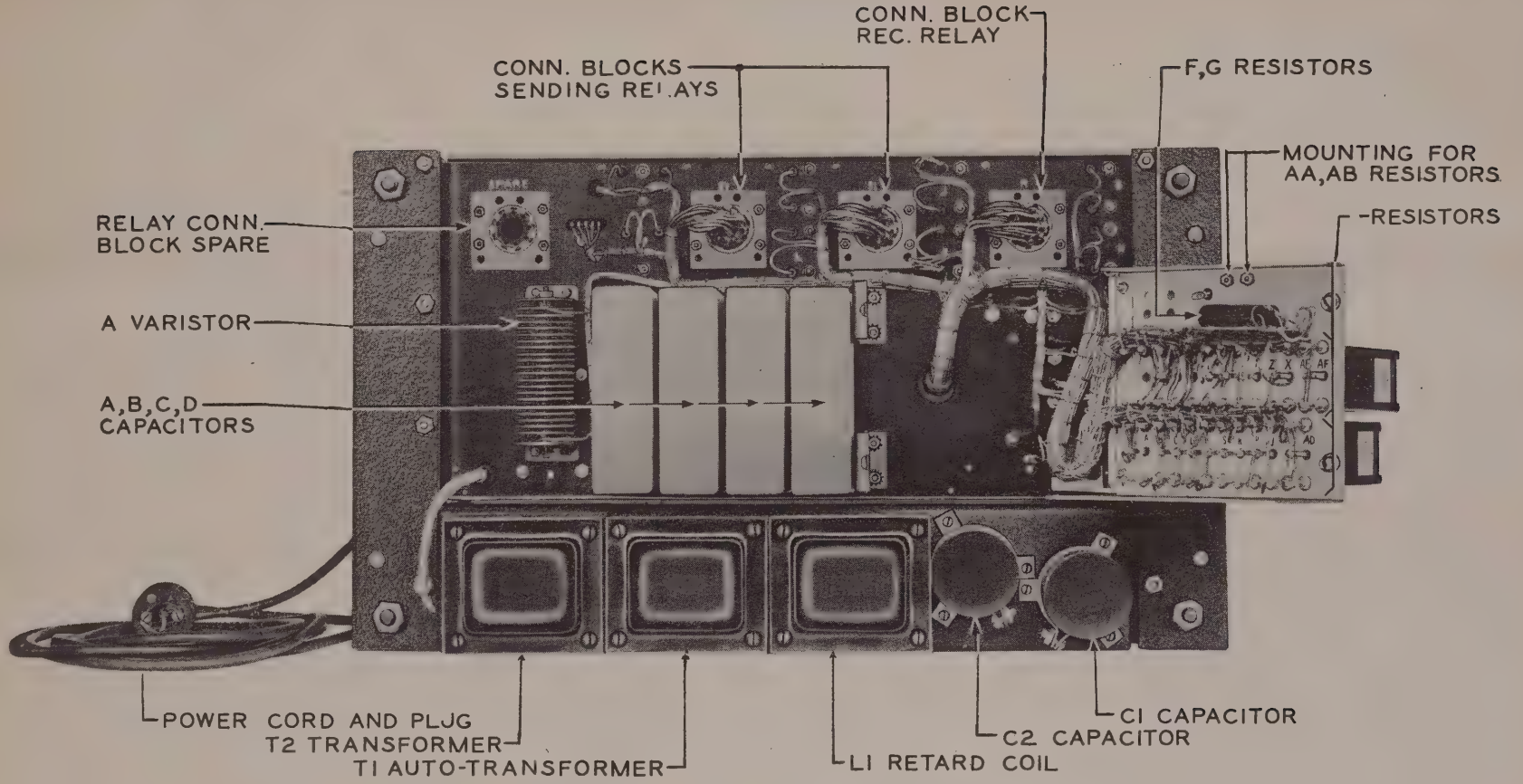


Figure 35 - Repeater TG-30 (Terminal), Rear View, Resistor Panel Open

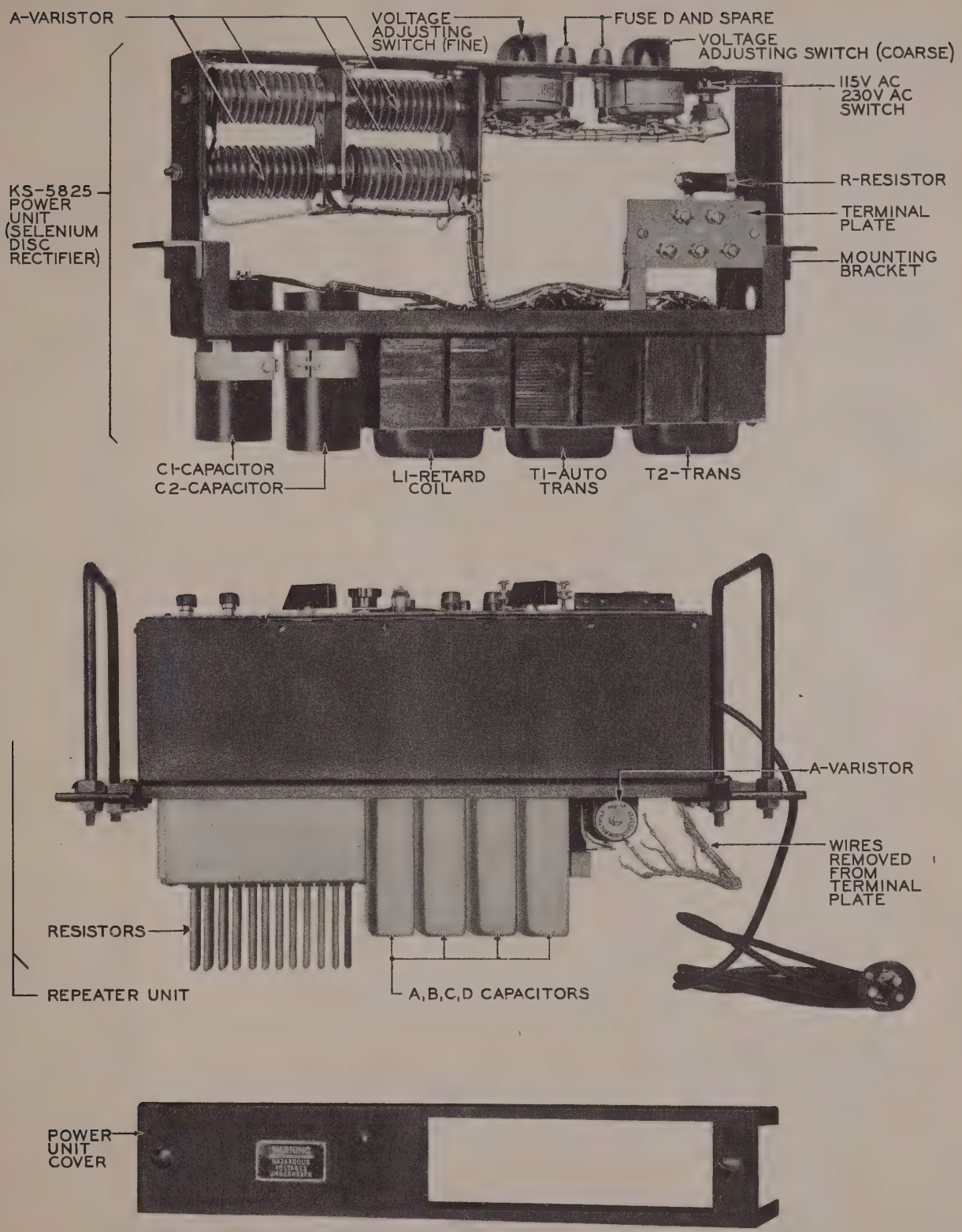


Figure 36 - Repeater TG-30 (Terminal), Power Unit Removed from Repeater Unit

9. a For a-c power supply.—Hold down MEAS VOLTS key (11) and turn ADJ VOLTS knobs (15) COARSE and FINE until meter reads 115V.

   b For d-c power supply (gas engine).—Hold down MEAS VOLTS key and adjust voltage at source. Turn over power cord if meter reads to left of zero.

10. a At a polar sending repeater (LINE switch in position 1).—Turn ADJ LINE CURRENT knob (7) FINE to maximum clockwise position. Turn COARSE knob clockwise to first position that gives at least 18 MA. Turn FINE knob as required to give 18 MA. Request distant terminal to send spacing signal for about 10 seconds by holding down break key of printer. Read space current and adjust space current as follows for types of lines as shown:

Space Current Reading on Meter	Readjust Space Current to be: 104 mil Copper-steel and Field Wire	104 mil Copper	80 mil Copper-steel
44 to 46 MA	No change	48	44 MA
40 to 41	43	45	42
36 to 37	41	43	41
32 to 33	39	39	40
28 to 29	37	37	38

Refer to instruction book for more complete table.

   b At a 2-path polar repeater (LINE switch in position 3).—Adjust current in sending line to 30 MA by ADJ LINE CURRENT knobs.

11. a Adjust local current in connected equipment.

Switchboard BD-100, Line Unit BE-77-A or Printer Station	60 MA
Telegraph Terminals CF-2-( )(Carrier)	60 MA
Repeater TG-29 (Electronic Regenerative)	30 MA

   b Repeat 9, 10, and 11 and readjust as required.

SERVICE MAINTENANCE

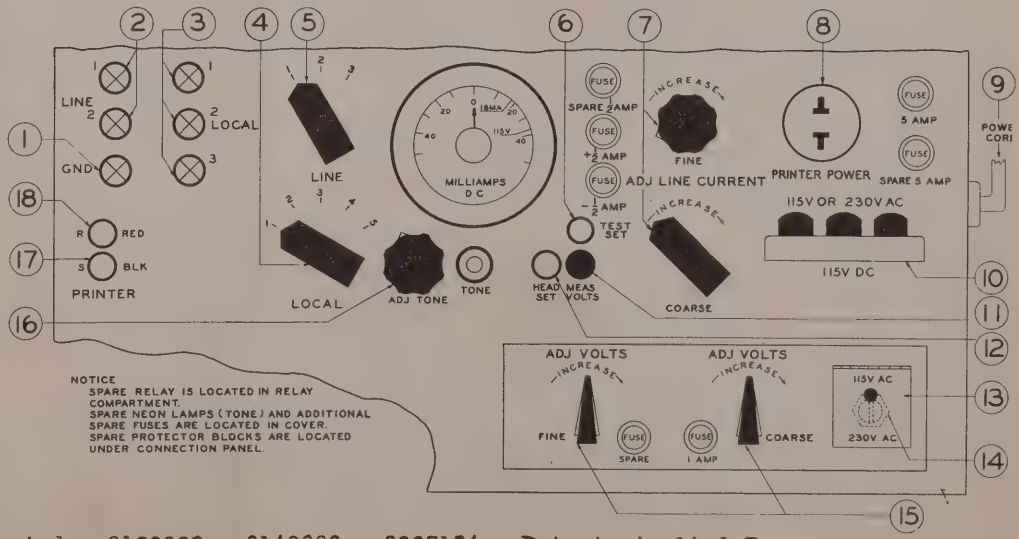
Maintain voltage adjustment at 115V.

All line current adjustments should be according to paragraph 10.

MISCELLANEOUS

Manual Telegraph Operation.—Remove all printer cords. Connect Headset to HEADSET jack (12). Turn ADJ TONE knob (16) to suit while operating telegraph key.

Polar Relay Testing.—Refer to instruction book.



Patented: 2133380 - 2143000 - 2237154. Patents Applied For

OPERATING INSTRUCTIONS - REPEATER TG-30 (TERMINAL)

LINE-UP PROCEDURE

OPERATION	READ PARAGRAPH
1st CONNECT GROUND WIRE	1
2nd CONNECT LINE WIRES	2
3rd CONNECT PRINTER OR LOCAL WIRES	3
4th SET LINE SWITCH	4
5th SET LOCAL SWITCH	5
6th SET ADJ LINE CURRENT SWITCH (COARSE)	6
7th THROW POWER SWITCHES	7
8th CONNECT POWER CORD	8
9th ADJUST VOLTAGE	9
10th ADJUST LINE CURRENT	10
11th ADJUST LOCAL CURRENTS AND READJUST VOLTAGE AND LINE CURRENT	11

1. Connect ground wire to GND binding post (1).

2. Connect line wire to LINE 1 binding post (2) for polarential operation. Connect sending line to LINE 1 binding post and receiving line to LINE 2 binding post for 2-path polar operation.

3. a Printer TG-7-( ).—Connect red plug to RED jack R (18), connect black plug to BLK jack (17) connect printer power cord to PRINTER POWER receptacle (8).

   b Local Wires.

   (1) With Switchboard BD-100 or Line Unit BE-77-A or Printer Station.—Connect wire to LOCAL 1 binding post (3).

   (2) With Telegraph Terminal CF-2-( )(Carrier).—Connect LOCAL 1 binding post to SL and LOCAL 2 binding post to RL in carrier terminal.

   (3) Intermediate Operation with Two Repeaters TG-30.—Connect binding posts LOCAL 1 to LOCAL 1, LOCAL 2 to LOCAL 2, and LOCAL 3 to LOCAL 3.

   (4) With Repeater TG-29 (Electronic Regenerative).—Connect binding posts LOCAL 1 to 1 LINE A and LOCAL 2 to 2 LINE A from one Repeater TG-30. Connect LOCAL 1 to 1 LINE B and LOCAL 2 to 2 LINE B from other Repeater TG-30 if employed.

4. Turn LINE switch knob (5).

   Position 1 for Polarential, Polar Sending (Terminal A)
   Position 2 for Polarential, Differential Sending (Terminal B)
   Position 3 for 2-path Polar
   Use same position of LINE switch for both repeaters at an intermediate point.

5. Turn LOCAL switch knob (4).

   Position 1 for Printer TG-7-( ) or Manual Telegraph Operation
   Position 2 for Switchboard BD-100 or Line Unit BE-77-A or Printer Station
   Position 3 for Telegraph Terminal CF-2-( )(Carrier)
   Position 4 for Intermediate Operation (Direction A with Printer, if required.)
   Position 5 for Intermediate Operation (Direction B without Printer)
   Position 5 for Repeater TG-29 (Electronic Regenerative)

6. Turn ADJ LINE CURRENT switch knob (7) COARSE to maximum counterclockwise position if LINE switch is in position 1 or 3.

7. a If power supply is a-c.—Open panel (13) and throw switch (14) to 115V AC or 230V AC as required. Throw power switch (10) to 115V OR 230V AC position. A-c power must be 50 to 60 cycles.

   b If power supply is d-c.—Throw power switch (10) to 115V DC position.

8. Connect power cord (9) to power supply.

9. a For a-c power supply.—Hold down MEAS VOLTS key (11) and turn ADJ VOLTS knobs (15) COARSE and FINE until meter reads 115V.

   b For d-c power supply (gas engine).—Hold down MEAS VOLTS key and adjust voltage at source. Turn over power cord if meter reads to left of zero.

10. a At a polar sending repeater (LINE switch in position 1).—Turn ADJ LINE CURRENT knob (7) FINE to maximum clockwise position. Turn COARSE knob clockwise to first position that gives at least 18 MA. Turn FINE knob as required to give 18 MA. Request distant terminal to send spacing signal for about 10 seconds by holding down break key of printer. Read space current and adjust space current as follows for types of lines as shown:

Space Current Reading on Meter	Readjust Space Current to be: 104 mil Copper-steel and Field Wire	104 mil Copper	80 mil Copper-steel
44 to 46 MA	No change	48	44 MA
40 to 41	43	45	42
36 to 37	41	43	41
32 to 33	39	39	40
28 to 29	37	37	38

   Refer to instruction book for more complete table.

   b At a 2-path polar repeater (LINE switch in position 3).—Adjust current in sending line to 30 MA by ADJ LINE CURRENT knobs.

11. a Adjust local current in connected equipment.

Switchboard BD-100, Line Unit BE-77-A or Printer Station	60 MA
Telegraph Terminals CF-2-( )(Carrier)	60 MA
Repeater TG-29 (Electronic Regenerative)	30 MA

   b Repeat 9, 10, and 11 and readjust as required.

SERVICE MAINTENANCE

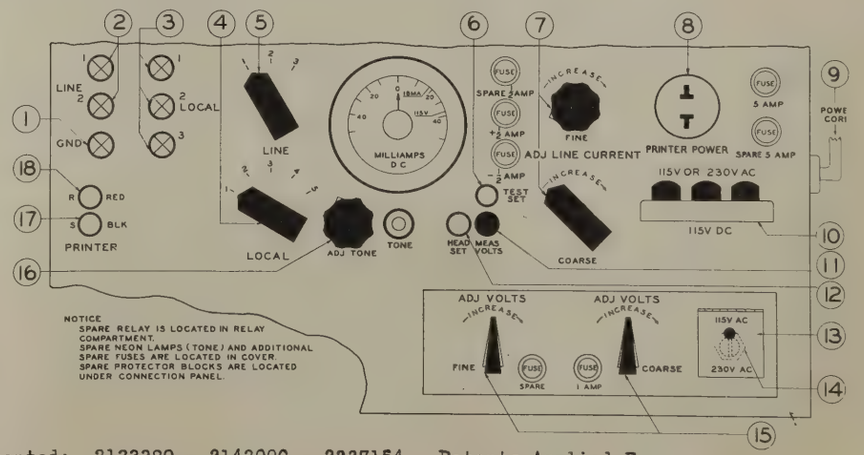
Maintain voltage adjustment at 115V.

All line current adjustments should be according to paragraph 10.

MISCELLANEOUS

Manual Telegraph Operation.—Remove all printer cords. Connect Headset to HEADSET jack (12). Turn ADJ TONE knob (16) to suit while operating telegraph key.

Polar Relay Testing.—Refer to instruction book.



Patented: 2133380 - 2143000 - 2237154. Patents Applied For

Figure 37 - Operating Instructions, Repeater TG-30 (Terminal)

CIRCUIT NOTES.

101. ALL RELAYS SHALL BE ADJUSTED TO MEET THE REQUIREMENTS OF THE 1-193- A TEST SET.

102. WHEN THE PRIMARY SOURCE OF POWER IS 230V. 50 TO 60~ OPERATE THE 115V.-230 V. SWITCH TO THE 230V POSITION AND OPERATE THE AC-DC SWITCH TO A-C BEFORE CONNECTING THE SET TO THE POWER SUPPLY. WHEN THE PRIMARY SOURCE OF POWER IS 115V, OPERATE THE 115V-230V. SWITCH TO THE 115V POSITION AND OPERATE THE AC-DC SWITCH TO THE REQUIRED POSITION BEFORE CONNECTING THE SET TO THE POWER SUPPLY.

103. WHEN AN A-C SOURCE OF POWER IS USED, ADJUST THE RECTIFIER VOLTAGE TO 115V. BY MEANS OF THE (ADJUST VOLTS) KNOBS ON THE SET. THE VOLTAGE IS INDICATED ON THE METER WHEN THE (MEAS VOLTS) KEY IS HELD DEPRESSED.

104. WITH THE CKT. IN THE MARKING CONDITION, ADJUST THE LINE CURRENT TO 18 MILS FOR POLAR SENDING OR TWO PATH POLAR OPERATION.
THE LINE CURRENT IS ADJUSTED AT THE DISTANT TERMINAL WHEN REPEATER IS ARRANGED FOR POLAR RECEIVING.

105. THE (LINE), (LOCAL), AND (ADJ LINE CURRENT) SWITCHES ARE SHOWN IN POSITION 1. WHEN THE SWITCHES ARE OPERATED TO HIGHER NUMBERED POSITIONS, THE CONTACTS REMAIN STATIONARY AND THE RING SEGMENTS TURN IN A COUNTERCLOCKWISE DIRECTION.

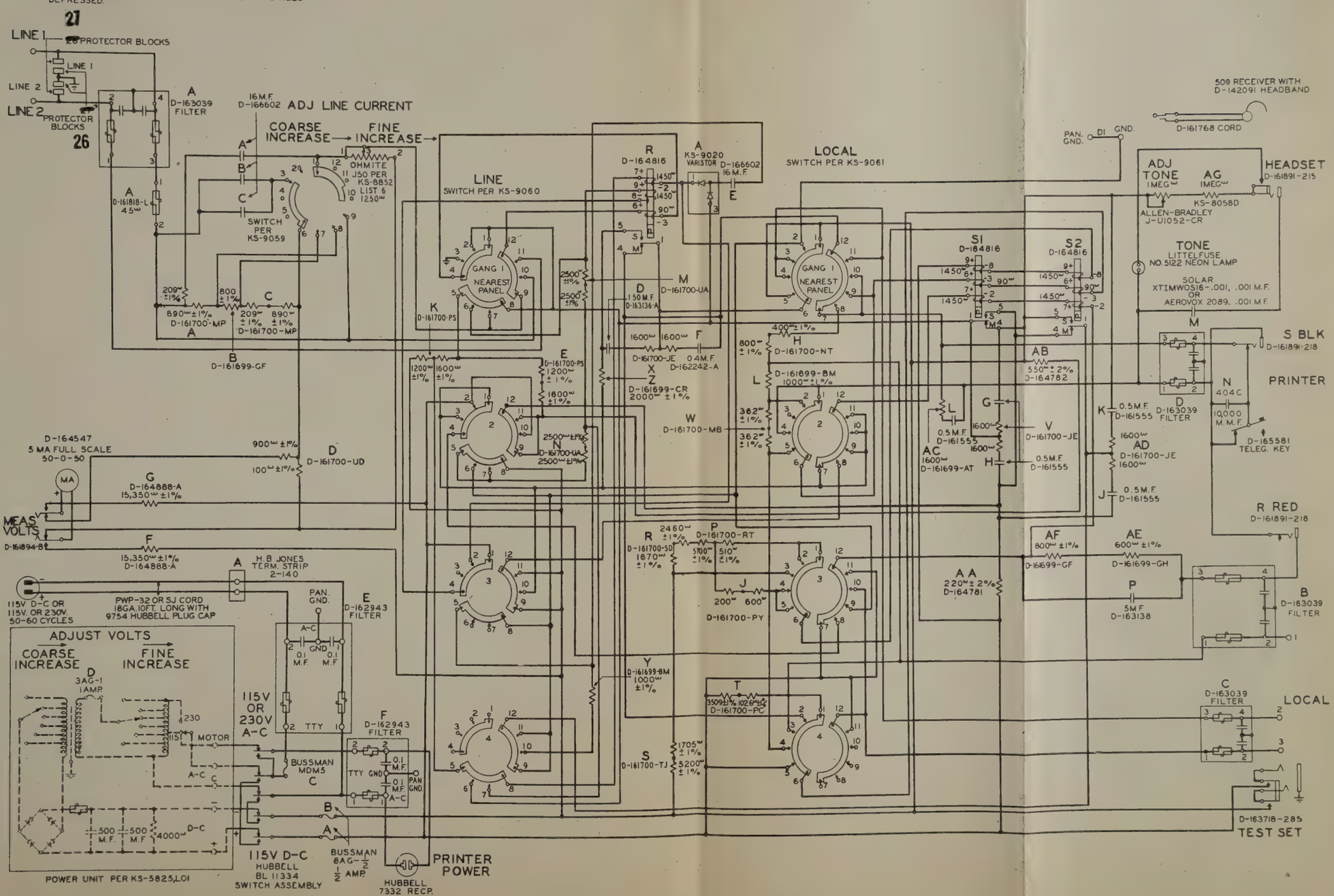


Figure 38 - Schematic, Repeater Circuit

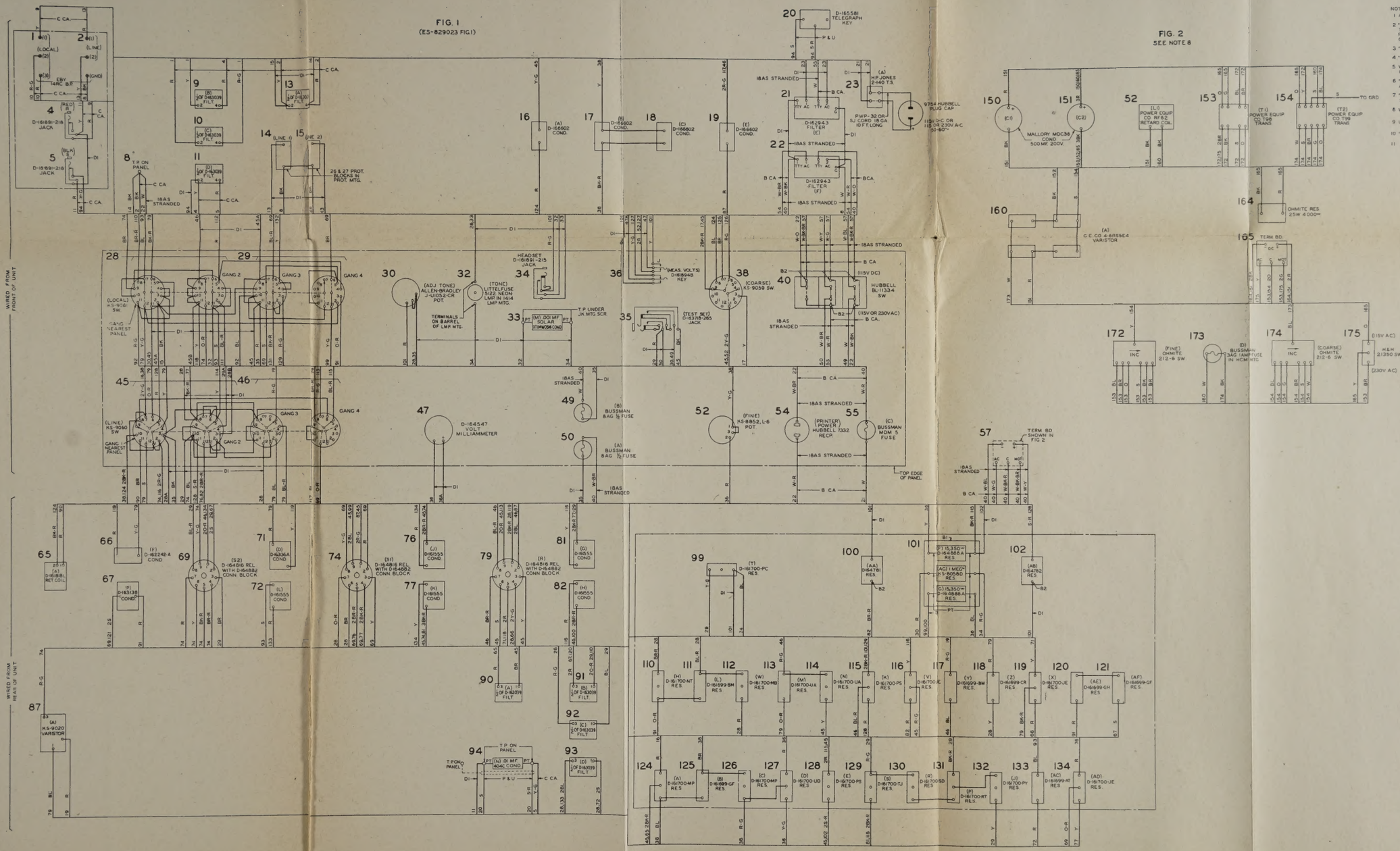


FIG. 1
(ES-829023 FIG.1)
FIG. 2
SEE NOTE 8
WIRED FROM FRONT OF UNIT
WIRED FROM REAR OF UNIT
NOTES:
1 ALL WIRING IS 22AM UNLESS OTHERWISE SPECIFIED
2 "D1" WIRING IS 6 22AM WIRE, RUN DIRECTLY FROM TERMINAL TO TERMINAL IN THE SHORTEST POSSIBLE MANNER AND INDEPENDENT OF ALL OTHER LEADS
3 "B1" EDGE OF RES.MTG NEAREST PANEL
4 "B2" TERM NEAREST PANEL
5 WIRES NOT OTHERWISE SPECIFIED RUN IN "A" CABLE
6 "PT" DENOTES LEADS FURNISHED AS PART OF APPARATUS
7 "J" END OF KEY NEARER HINGE LOOKING AT TERM. SIDE.
8 WIRED BY MANUFACTURER PER KS-5825, FIG 2.
9 LEADS DESIGNATED "U" SHALL BE 22P WIRE
10 "P" DENOTES PAIR.
11 DENOTES SHIELD CONNECTION.

Figure 39 - Wiring of Circuits, Circuit Label